POWER PLANT ENGINEERING

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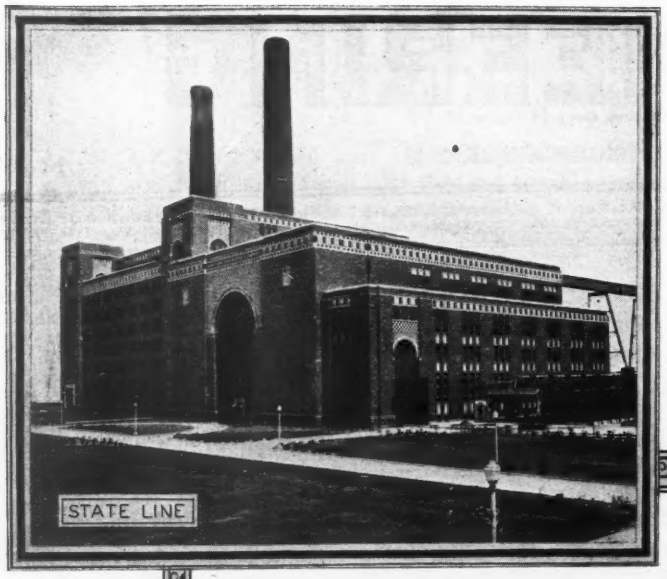
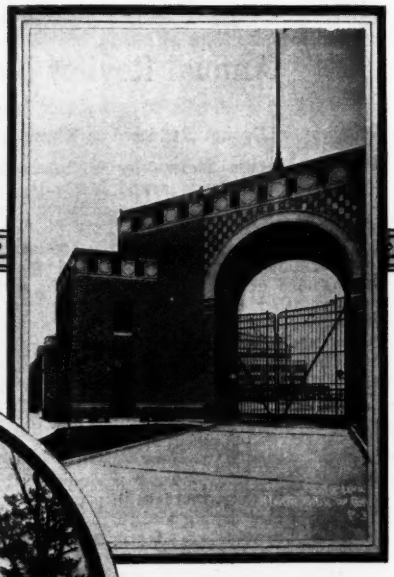
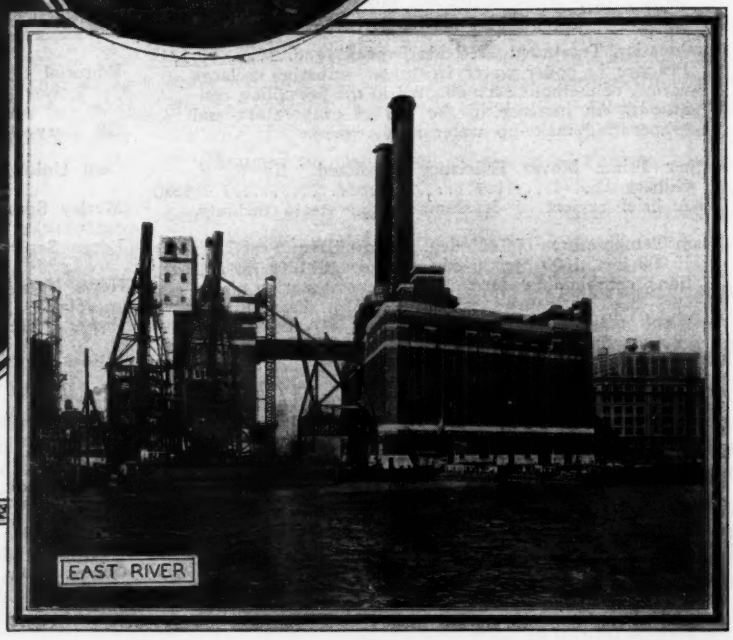
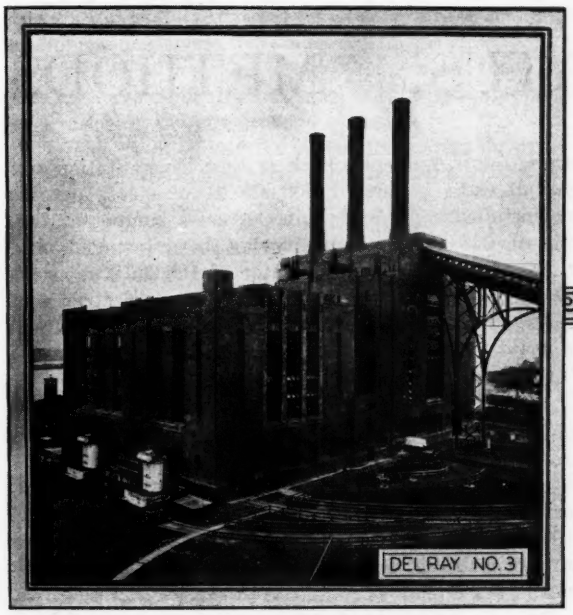
Progress in D



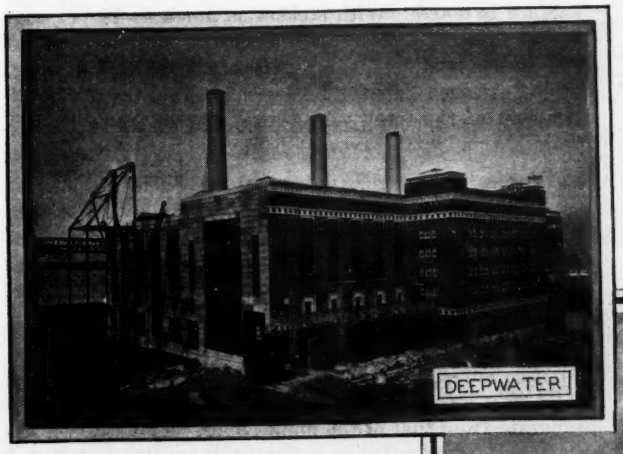


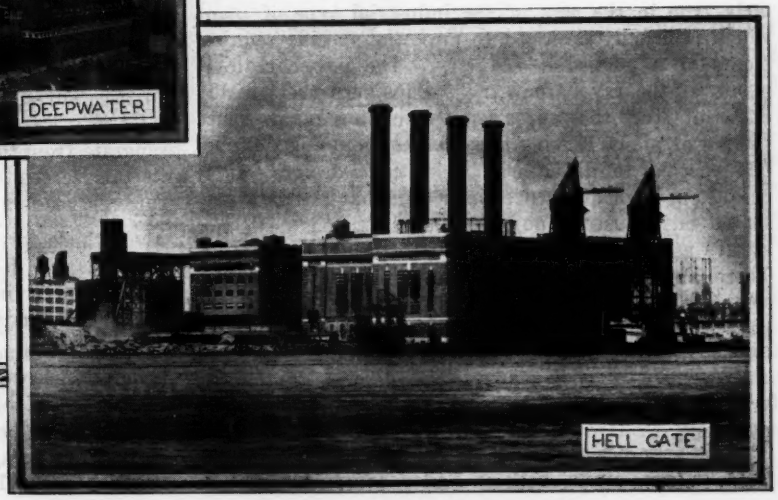


n Design Reflected by these Stations



The seven stations shown on these two pages reflect the progress of power plant development during the past year. In these stations are incorporated all the major improvements and advances and in their performance higher economy is to be expected. ¶ At State Line there is installed not only the largest turbine unit in the world but also a new and novel type of switchgear. To East River is awarded the honor of possessing the largest boilers in the world—units having capacities of 800,000 lb. of steam per hr. This same station also has the largest single electric generator. ¶ Deepwater Station and Holland share equal honors in being the first two stations using 1200 lb. steam pressure throughout and Delray is the first station in this country using a steam temperature of 1000 deg. F. ¶ These are but a few of the outstanding features of power plant progress this year.





Year's Progress *shown by* REFINEMENTS *and* IMPROVEMENTS *in* APPARATUS *and* METHODS

A STUDY OF THIS year's activity in the power plant field reveals many interesting developments, and from even a casual familiarity with these developments it is evident that, in the manner of a national cigarette advertising slogan, "Progress has been made." While this year's developments include several startlingly new principles, progress, on the whole, is marked rather by a consistent improvement and refinement of equipment and methods and in a more thorough understanding of the problems involved in the conversion of the energy in fuel into mechanical and electric power. The general trend is toward still larger units. Efficiencies of individual equipments have been raised and more thorough methods of recovering the heat lost in conversion processes have brought overall efficiencies of plants up.

Review Based on 23 Plants

This year, our review of power plant developments is based upon a survey of the equipment installed in, and the design features of 23 carefully selected plants located throughout the country. These plants are listed in the accompanying tabulation. Of these 23 plants, 13 are classified as Central Stations and 10 as industrial power plants. Among those listed in the first group will be found, the largest and most notable plants built during the year while those in the latter group represent typical industrial power plant practice today. Naturally, in a survey of this kind where the data collected must be presented in tabulated form, it is not always possible to devise forms which will be adapted to the conditions existing in all plants. This is particularly true in the case of the industrial type of plant which is usually designed to meet the specific requirements of a particular industry. The power requirements of the rayon industry for instance are entirely different from those of a copper refining plant, hence the power plants serving these respective industries may be expected to differ widely in their design. It is because of such differences in design that the data presented on industrial power plants in this issue is not always as complete as we should be pleased to have it. There are certain basic features, however, which are common to all classes of plants and these features we have endeavored to incorporate in the tabulations contained in this issue.

Large Units Installed

This year has witnessed the installation of some extremely large units, both in boiler equipment and in generating equipment. Both at East River Station and at Hell Gate, boilers of 800,000 lb. of steam per hr. are installed. At State Line, a cross compound turbine of 208,000 kw. capacity has been installed, and at East River, a single generator of 160,000 kw. marks the highest capacity yet attained in an electric generator. Transformers also have increased in size, as will be noted by referring to the section on Electric System Practice.

In the production of steam from fuel, furnaces and fuel burning equipment have undergone steady improvement. Stokers as large as 15 retorts wide and 57 tuyeres deep have been installed. A new type of pulverizing mill known as the table mill has been installed in several plants. Horizontal firing with turbulent burners is being used with both unit and central systems.

Dissemination of ash dust by pulverized coal plants is still a problem with some plants. Washers, electrostatic precipitators and mechanical methods are being used to solve this problem.

In furnace practice, larger amounts of water-cooled surface is noted. With stokers as much as 14 per cent of the heating surface is water wall and at three of the larger stations using pulverized coal, the water-cooled furnace surface becomes as much as 25 or 30 per cent of the total. As a general rule, however, this ratio is smaller, the average being about 10 per cent.

Values of heat release are, on the whole, higher this year than they were last year. For pulverized coal plants they range between 20,000 and 30,000 B.t.u. per cu. ft. per hr. For stoker-fired plants, the values range between 33,000 and about 55,000 B.t.u. per cu. ft. per hr.

One of the outstanding features of furnace design this year is that used at Delray. Here the water-cooled furnace surface, constituting about 14 per cent of the total is a water and steam circulating surface entirely separate from that of the main boiler. Any steam made in this screen boiler is collected in a drum and fed through headers to the upper boiler drum.

Methods for treatment of feedwater have undergone little change. The use of evaporators has increased and systems involving combinations of a wide variety of treating methods find favor.

While there has been no increase in the highest boiler pressures used, there has been a general increase in the use of high pressures. Two stations built this year, Deepwater and Holland, use 1200 lb. boiler pressure exclusively. An interesting development in boiler practice is the 1000 deg. F. total temperature installa-

tion at Delray No. 3. The advantages of high temperatures rather than high pressures have not been given much consideration by American engineers and the operation of the Delray units will be regarded with great interest.

Heat Balance Developments

Extraction heater and evaporator practice is now fairly well standardized, four stages of extraction are not uncommon while five stages are in use at State Line. Practically all stations bleed superheated steam and heaters have been developed to take advantage of the heat head of the superheated steam.

Pressures in industrial plants are increasing rapidly in order to get better balance of the steam and electric outputs. Six and eight hundred pound plants are in service while 1200 and 1840 lb. plants are under construction. Accumulators and extraction mixed pressure turbines are an important part of modern industrial power plant design. At least two stations are using high-pressure evaporators using 400-lb. steam for furnishing 150-lb. process steam.

Coöperation of public utilities with industrial companies for the sale of steam and power will undoubtedly have an effect on the heat balance layout of both types of stations. This arrangement exists at Deepwater. Combination gas and steam reheat is being used successfully to give control of high pressure plant steam reheat temperatures.

In the turbine field, the development of the steeple compound 1200-lb. turbine with the high-pressure element mounted on top of the low, is the most striking development of the year. Both central station and industrial plant turbines of this type are built or have been ordered.

Installation of a 10,000-kw., 1000-deg. F. turbine at Delray is of great interest and is bound to play an important part in future progress. At State Line, the world's largest, a 208,000-kw. three element cross compound unit is in service. The 75,000-kw. single cylinder turbine at Cahokia and the 160,000-kw. tandem compound unit at East River break the record for their respective classes.

Use of welded condenser shells is probably the most important development of the year in the condenser field. The heart shaped shell of this unit is hung from the turbine and the tubes and water boxes are supported separately with expansion joints between the shell and each water box.

Surface condenser sizes continue to decrease slowly —the lowest figure being that at East River, with 0.56 sq. ft. per kw. Single and two pass designs are about evenly divided.

Progress in the design of electric generators continues smoothly. The trend is toward larger units and this has brought out a number of new features, the most interesting of which are the higher voltages and the double winding arrangement. While the highest voltage unit placed in service in this country this year, the 22,000-v. machine at State Line, is no higher than those installed at Powerton the preceding year, a 33,000-v. machine is in operation with good results in England. Hydrogen cooling has not yet been applied to generators but this is probably the next important step in the art of generator design.

Switchgear is undergoing a gradual transformation as will be noted from the State Line layout, which looks no more like the conventional layout of a few years back than did the isolated phase arrangement resemble the group phase layouts of former days. Without question, the most important single development of the year in this field was that of the Deion circuit breaker. Incorporating an entirely new principle of circuit interruption, this breaker will play an important part in the future development of switchgear.

In the internal combustion engine field, an increase in the use of Diesel engines of large sizes is noted. Marked advance in standardization not only in general design but also in Diesel parts brought about by the manufacture of such parts in specialized factories, and an increase in the use of auxiliaries in Diesel plants are the outstanding features of Diesel development.

LIST OF POWER PLANTS INCLUDED IN SURVEY

Name of Station	Company	Location	Consulting Engineers
Deepwater	American Gas & Electric Co. United Gas Improvement Co.	Deepwater, N. J.	Stevens & Wood, Inc.
Holland	General Gas & Elec. Co.	Holland, N. J.	W. S. Barstow & Co., Inc.
Station A	Pacific Gas & Elec. Co.	San Francisco, Cal.	Pacific Gas & Elec. Co.
Hell Gate, 1929-30 Addition	New York Edison Co.	New York, N. Y.	Thos. E. Murray, Inc.
East River Addition	New York Edison Co.	New York, N. Y.	Thos. E. Murray, Inc.
State Line	State Line Generating Co.	Hammond, Ind.	Sargent & Lundy, Inc.
Cahokia	Union Electric Light & Power Co.	St. Louis, Mo.	Union Elec. Lt. & Power Co.
Delray No. 3	Detroit Edison Co.	Detroit, Mich.	Detroit Edison Co.
Ohio River	Southern Indiana Gas & Elec. Co.	Evansville, Ind.	Stevens & Wood, Inc.
Gorgas Addition	Alabama Power Co.	near Birmingham, Ala.	Alabama Power Co.
Riverbend	Duke Power Co.	near Charlotte, N. C.	W. S. Lee
English Addition	United Illuminating Co.	New Haven, Conn.	Westcott & Mapes, Inc.
Fremont	Municipal	Fremont, Neb.	Burns & McDonald
Waukegan N. S. C. & C. Co.	North Shore Coke & Chemical Co.	Waukegan, Ill.	Wm. A. Baehr Organization, Inc.
St. Paul's	St. Paul's school	Concord, N. H.	French & Hubbard
Viscose	Viscose Co.	Meadville, Pa.	Viscose Co.
New Haven P. & B.	New Haven Pulp & Board Co.	New Haven, Conn.	Westcott & Mapes, Inc.
Harriman	Harriman Co.	Harriman, Tenn.	Management Eng. & Dev. Co.
Crocker Burbank	Crocker, Burbank & Co. Assn.	Fitchburg, Mass.	Francis J. Sill
American Bemberg	American Bemberg Corp.	Elizabethton, Tenn.	Lockwood, Green
Champion International	Champion International Co.	Lawrence, Mass.	Chas. T. Main, Inc.
Miami Copper Co.	Miami Copper Co.	Miami, Ariz.	Griggs, Fuller & Clark
American Glanzstoff	American Glanzstoff Corp.	Elizabethton, Tenn.	Lockwood, Green

Boiler and Furnace Development

Pressures becoming standardized. Temperatures Tend to Rise. Overall Plant Efficiency should be kept in mind.

By William Bradford
Director of Engineering
Edge Moor Iron Co.

DURING THE PAST year has developed the culmination of one of the most rapid and spectacular periods of development in the field of boiler and furnace design that has ever taken place. During the year, however, a tendency for conditions to settle down to some extent has been evident or, to use the expression of a prominent designing engineer, conditions are beginning to "jell." Order is beginning to come out of the chaos of the last five years. This seems to be especially true in respect to operating pressures.

Pressures and Temperatures

In the central station field, designers are separating into two general camps. On the one hand are the champions of the simpler, moderate pressure range from 400 to 500 lb. and on the other, those who favor the high pressure range from 1200 to 1400 lb. In both camps, agreement seems to be rather close as to the most suitable final superheated steam temperature and this has been fairly well stabilized at a maximum of 750 deg. F. Recently, however, there has been a tendency to push this up and with the use of alloy material in superheater construction, there should be no great difficulty in doing this. It must, however, be remembered that the valves, fittings and pipe lines beyond the superheater must be designed for this higher temperature and, at the present prices of alloy materials, its use here can hardly be justified.

It is, of course, possible that carbon steel can be used with absolute safety above the 750-deg. limit but recent investigations of the behavior of this material at elevated temperatures, indicates that the safe limit is not far above this point.

Any increase in this final steam temperature will, of course, raise the pressure limit of the moderate pressure field so that we will probably see this pushed up to 600 or 650 lb. in the near future.

Resuperheat seems to be the most important single factor in the problem responsible for setting the limit, especially of the moderate pressure range, since 500 lb. and 750 deg. F. are apparently the maximum operating conditions for condensing turbines, without resorting to the reheat cycle. The elimination of the intermediate pressures between 500 to 1200 lb. results from the necessity of obtaining sufficient benefit from the reheat cycle to justify its cost, which can only be done by increasing the pressure to at least 1200 lb.

Both the moderate and high pressure camps have a number of ardent and sincere champions among the prominent designing and operating engineers and they have developed a mass of calculations, curves and other data to justify their respective positions. Some of this data consists of actual operating results covering a sufficient period of time to prove conclusively that design predictions have been fulfilled. The difficult problem, however, is to obtain results of this kind from two or more plants which will be truly comparative.

Overall Efficiency the Final Test

Final judgment as to relative results must, of course, be based on the overall efficiency obtained which is commonly expressed as B.t.u.'s per kw-hr. But, in obtaining these figures, it is necessary to take into account

a number of variables, which are in no way related to the operating pressure and which may affect the overall results even more than would the change of pressure from one field to the other.

As an illustration of the possibilities in this direction, may be cited the results recently obtained in a comparatively old station with an operating pressure below 250 lb. By improvement in stoker operation and firing conditions and adjustment in station load factor, the overall plant operation for the month of October was brought down to slightly less than 14,800 B.t.u. per kw-hr., which was almost exactly the figure predicted, within the last twelve months, for one of the new 1200 to 1400-lb. stations.

This shows clearly what a marked effect local and special operating conditions may have upon the final result and indicates how carefully all of these must be considered in determining the final plant design. Particularly is this true in the case of the smaller and more isolated stations where base load is unknown. Too often in these cases, the designers are led astray by the glamour of high pressures and complicated auxiliaries which are entirely justified in the super-power plant but which prove only an added source of expense in the smaller plant.

Heat Conservation and Balance

Although, as has been stated, pressures seem to be settling down into two general classes in the central station field, an entirely different condition exists in the industrial field. An increasing number of industries, whose only requirement for steam is for the generation of power, are finding it to their advantage to purchase their power from central stations. There are a large number of industries, however, which have a demand for steam for heating or process work in addition to power generation and it is here that some of the most rapid high-pressure developments have occurred. Careful study of the balance between electrical energy and process steam requirements has resulted recently in the installation of a number of steam plants ranging in pressure from 400 to 800 lb. and, at the present time, one industrial plant is under construction which will operate at 1800 lb.

Still another group of industries which consume large quantities of fuel for their heating, melting, calcining or other processes, are finding it increasingly profitable to utilize the heat still remaining in the waste gases for steam production. This recovery of waste heat has, of course, been a standard practice in the iron and steel industry for many years. It has also been quite widely adopted by the cement industry and here, in the majority of plants, it is possible to recover sufficient heat from the waste gases to provide all the power required for operation of the entire mill.

More recently, the oil refineries, pulp mills, chemical plants, and others have found waste heat boiler installations profitable and, as fuel prices advance, it will be possible to extend the field into other industries having smaller quantities of waste gases available.

Furnace Design

In the field of furnace design, we have also been passing through a period of most rapid development. With improvement in combustion conditions, the use of water-cooled walls has been extended to include all types of furnaces for all classes of fuels, solid, liquid and gaseous.

Here, however, as in the boiler field, there are indications that conditions are beginning to "jell." Engineers are getting back to first principles and are again considering water-cooled furnace design on the basis for which it was originally conceived, that is, for the protection of furnace refractories or the reduction of furnace maintenance costs.

With the increasing amount of actual operating data available, they are able to make accurate comparisons between increased investment charges and reduced maintenance costs and as a result are arriving at a much saner basis of design.

This is particularly true in the case of the smaller central stations and industrial plants where load conditions and operating personnel do not warrant the introduction of too many refinements or complications.

In general, the present conditions in the boiler and furnace field are in perfect accord with conditions in all other lines of human endeavor resulting from the rapid and almost frenzied advance of science during the last few years. Engineers have always been the steadying influence and it is most essential at this time that they keep their feet on the ground and not let themselves be swept along by the popular tide. Progress must not be halted but it would seem that the time is approaching when a careful weighing of actual results must take place and the facts thus obtained, applied in a sane way to future designs.

We have recently witnessed the results of the frenzied conditions in the financial world. The World Powers are discussing limitations of armaments and of competitive building. Is it not time that engineers stopped long enough to take stock of the situation and decided whether a policy of limitation of competitive building would not be wise in the power plant field?

In a recent installation of welded heating pipe for a small New York apartment building, a problem arose as to location of a return pipe for a vacuum vapor system in the basement. A door was encountered in such position that it seemed necessary to run the pipe directly across the middle of the door frame in order to bring the condensation back to the boiler. Running the pipe below the floor level was impossible and still maintain the proper return of condensate to the boiler. Finally the piping contractor devised a method by running a pipe down around the bottom of the door for the condensate, maintaining the proper pitch between the two ends of the loop so that after this loop was filled with condensate it would drain away to the boiler. A loop was also carried over the top of the door to convey steam and thus avoid any possibility of steam binding. This arrangement was easily constructed by the use of oxy-acetylene welding to form and join the two loops.

One significant feature in the growth of the natural gas industry during 1928 was that public utility companies, as reported by the U. S. Geological Survey, used 77,326,000,000 cu. ft. for generation of electricity, an increase of 23 per cent over 1927.

Developments in Combustion Equipment

LARGE STOKERS, INCREASE IN USE OF UNIT PULVERIZING MILLS AND OF MILL DRYING AND FURTHER USE OF HORIZONTAL TURBULENT BURNERS ARE FEATURES

DEVELOPMENTS during the year in combustion equipment have, for the most part, been the outgrowth of tendencies that began about two years ago, to which attention was called in the December 15, 1927 and 1928 issues of Power Plant Engineering. Concomitant with the development of the 1400-lb. pressure field and the use of larger boiler units and turbine units,

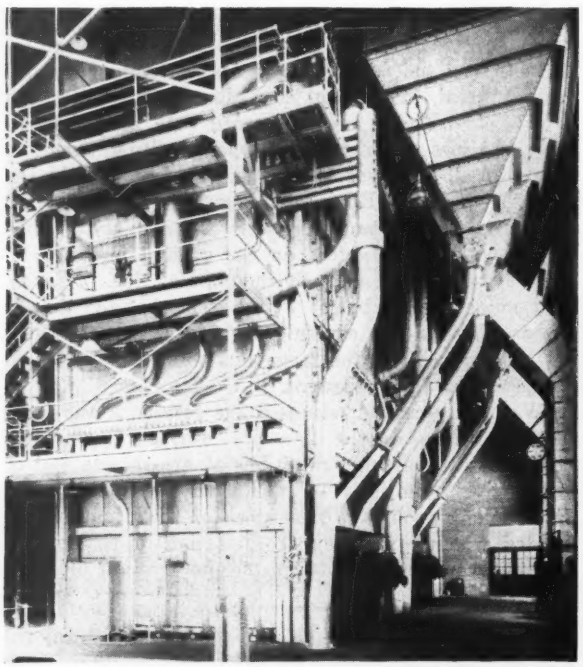


FIG. 1. STOKER-FIRED BOILERS AT OHIO RIVER STATION

there has been the development of stokers of high capacity, the increasing adoption of unit pulverizing mills, with mill drying replacing separately-fired dryers, and increasing use of horizontal types of turbulent burners.

Water-cooled furnaces, which will be discussed later, have made possible the operation of all types of coal-burning equipment in ways that could not have been attempted a few years ago.

SIZE OF STOKERS INCREASES

Stokers of large size shown in the accompanying tabulations are typified by the 15-retort, 57-tuyere units at Delray No. 3 designed to burn about 56 lb. of coal per sq. ft. per hr. Even these, however, are not the largest for some 65-tuyere stokers have been built and others 35 ft. wide. One manufacturer states that there is no reason why stoker-fired boiler units with a capacity of 1,500,000 lb. of steam an hour capacity will not be realized.

Other stokers tabulated include stokers of more moderate size ranging from the 35 and 25-tuyere units of Ohio River and English stations down to the industrial plant units 5 and 6 retorts wide and 21-25 tuyeres deep.

NEW TYPE OF STOKER DRIVE MECHANISM

It will be noted that the Delray stokers incorporate new driving mechanism of the straight-line type arranged so that drives for the coal feeding rams are entirely independent of the distributing pushers. Furthermore, the straight-line drive stroke of each individual pusher can be separately controlled. These stokers are set in furnaces equipped with screen boilers, which will be discussed later.

Other new stokers have been developed during the year, in both large and small sizes and in various types, as described in previous issues of Power Plant Engineering.

With a large stoker installation at the Allegheny County Steam Heating Co., three-roll clinker grinders

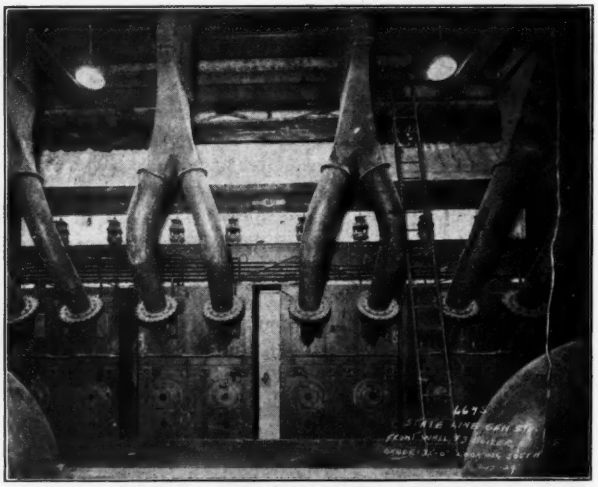


FIG. 2. EIGHT PULVERIZED COAL BURNERS OF THE TURBULENT TYPE SERVE EACH STATE LINE BOILER

are used. The clinker grinders at Ohio River station are driven by steam turbines, the first installation of this type. Also, a portable type of clinker grinder is now on the market.

IMPROVEMENTS IN STOKER CONSTRUCTION

Need for burning larger amounts of coal on stokers and the long travel of coal and waste products from coal hopper to grinder pit have required facilities for adjusting the motion of different parts of the fuel bed and for controlling windbox pressures and air flow under various subdivided stoker sections. These developments lead toward a greater use of steel and to more accurate machining of stoker parts than were previously justifiable. Means for supporting stoker fronts independent of the setting have been devised to aid maintenance work.

Combustion air is preheated for stokers in many cases; the maximum temperature used, however, is seldom much above 350 deg. Use of secondary or overfire air is frequent; the temperatures and pressures of this air and the sources of it vary widely with individual cases, as can be seen from the tabulation.

Trend Toward Mill Drying with Both Unit and Central Systems

Turning to the tabulation of pulverized coal, oil and gas burning equipment, we find trends a little more definite than with stoker equipment. Almost every kind of coal commercially available in this country has been pulverized and burned successfully. As can be seen, the usual practice is to crush or break the coal before pulverizing.

Coal dryers, however, have seldom been used in the newer plants; even where the central or bin system is employed, heated air introduced into the mills as primary combustion air or carrying air serves to dry the coal sufficiently to permit good pulverization and transportation. Initial moisture in coals to be pulverized runs as high as 10 per cent at Deepwater and Cahokia but for the most part it is seldom over 5 per cent in the other stations noted. Moisture as fired is usually 2 or 3 per cent.

Pulverizing mills are of various types and capacities, usually driven by motors. Power consumption for pulverizing, in kilowatt-hours per ton, as given by some of the plants, varies between 10.5 given for Riverbend and 16.5 for the unit mills at Deepwater or 17 for those at Crocker Burbank Co. The range of these figures is much the same as it has been in previous analyses; the data should not be compared too closely, however, as it is not stated in each case whether the figure covers all factors or not.

Table Mill Is Introduced

A new type of pulverizing mill, the table mill, is being introduced this year in some of the larger stations. One of these is used on one boiler at State Line in conjunction with air-separation mills, the latter being used on all the other boilers. At Deepwater, each boiler in the A.G.E. section is served by one table mill and one pusher type mill. In the U.G.I. section of Deepwater, roller mills are used in a central system, with mill drying. The preferences of the two companies owning the station led to the use of the unit system in one-half of the station and of the central system in the other half, thus providing a most unusual basis for comparison of the two under almost identical operating conditions.

Direct firing without storage between mill and burners usually requires division of mill capacity as well as burner equipment into two or more units to insure reliability. Duplication of mills is also a benefit for control of fineness with varying ratings; mill power can also be controlled to some extent.

As noted, average fineness of pulverization is about 70 per cent through 200 mesh screen, although at Crocker Burbank Co., 80 per cent through 100 mesh is used.

Average size of boilers fired by the unit system appears to have increased in the last two years. Direct-fired boilers in ultility plants, however, are still considerably larger than those in industrial plants.

Horizontal Firing with Turbulent Burners

Trend towards horizontal firing with turbulent burners seems to coincide with the attempt to increase average heat liberation. Horizontal firing is used with both bin and unit mill systems, as is well illustrated at Deepwater. At East River an unusual burner arrangement is employed. In each furnace 20 turbulent burners fire vertically through the top arch of the furnace on each side and on the side walls a short distance below them, 20 auxiliary burners fire horizontally. This arrangement is intended to give high turbulence and good flame distribution, with high coal burning capacity for making 800,000 lb. of steam an hour per boiler unit.

Primary air with unit mill systems is usually introduced at the mill, where it also acts as drying air. In most of the cases, tabulated, this air is preheated.

PULVERIZED COAL, OIL, AND GAS BURNING EQUIPMENT

NAME OF STATION	*HEATING SURFACE SQ. FT. EA.	FURNACE VOLUME CU. FT. EA.	FUEL: KIND & B.T.U.	FUEL: PREPARATN	FUEL: % MOISTR INITIAL	FUEL: % MOISTR AS FIRED	DRYER	PULVERIZING MILLS: TYPE	PULVERIZING MILLS: NO. PER BLR.	PULVERIZING MILLS: CAP. TON PER HR.	PULVERIZING MILLS: DRIVE & POWER CONSUMED	PULVERIZING MILLS: FINE'S % THRO 200 MESH	BURNERS: TYPE	BURNERS: NO. PER BLR.	METHODS OF COOLING FURNACE WALLS	AIR SUPPLY: PRIMARY: % OF TOTAL	AIR SUPPLY: PRIMARY: WHERE INTRODUCED	AIR SUPPLY: PRIMARY: TEMP.	AIR SUPPLY: SECONDARY: % OF TOTAL	AIR SUPPLY: SECONDARY: WHERE INTRODUCED	AIR SUPPLY: SECONDARY: TEMP.	ASH DISPOSAL: FROM FURNACE	ASH DISPOSAL: FROM FLUE GAS
DEEPWATR	3-11302 3-11139	19080	PITTSBURGH 13500	HAMMER MILL	3-10	2	MILL DRYING	3 BLR. Δ U.S. BALL 3 BLR C.S. ROLLER	10 16		MOTOR 16.5 KW-HR MOTOR 14.0 KW-HR.	70 65	HOR. TURB. HOR. TURB.	4 6	WATER	10	AT MILL	250	85	BRNRS. LEAKGE	458	SLUICE	SOOT HOPPERS
HOLLAND	10122	18 500	PENNA.#9 WEBSTER 13 870	BREAKER	2,83	2,0	MILL DRYING	1 ROLLER 1 BALL	2	18 17	——	70	OPPOSED TURB.	6	WATER	15, 20	BELOW FEEDER	350	80 & 85	SEC. & TERT. AT BRNR.	?	SLUICE	SLUICE
STATION-A	12 318	15 100	OIL-18500 / LB GAS-1070 / CU FT	——	—	—	——	——	——	——	——	——	COMB. OIL & GAS	24	WATER	?					?	——	——
HELL GATE	38 896	45 100	POCAHONTAS 14000	CRUSHER	4-5	2-0	MILL DRYING	BALL	4	10	MOTOR 15.2 KW-HR/T.	70	HOR. TURB.	12	WATER	20	MILL	304	80	BURNR	304	SLUICE	YES
EAST RIVER	67 339	38 200	SEMI-BIT. 14 000	CRUSHER	4-5	2-0	STEAM HOT AIR IN MILL	ROLLER	CENT SYS.	25	MOTOR 10 KW-HR/T.	70	TURB. & AUX BRNR	20 20	PART WATER	25	BRNR	432	75	SIDE WALLS	432	SLUICE	ELECTRIC PRECIPIT.
STATE LINE	14 735	22 500	ILLINOIS	BREAKER	—	—	MILL	AIR	2	15	MOTOR	——	HOR. TURB.	8	WATER	—	MILL	——	——	BRNRS		SLUICE	DUST REMOVERS 3 TYPES
CAHOKIA	19 836	14 650	ILLINOIS 10 800	CRUSHER BREAKER	10,0	10,0	MILL DRYING	IMPACT	2	8	MOTOR	65	HOR. TURB.	4	WATER	60	MILL	235	40	BRNR.	235	SLUICE	NONE
GORGAS	33 805	24 000	ALA. BIT. 11 800	BREAKER CRUSHER	1-5	—	MILL DRYING	ROLLER CENT-SYS.	TOT. 3	15	MOTOR	80	CYL. TURB.	8	WATER	15	BURNER FEEDRS	180	85	BRNR.	380	SLUICE	NONE
RIVERBEND	38852	19950	W.VA-KY-TENN 13 200	CRUSHER	5-0	—	MILL DRYING	AIR SEP.	3	10	MOTOR 10,5 KW-HR/T.	70	HOR. TUR.	6	WATER	25	MILL	300	75	BRNR.	480	SLUICE	NONE
VISCOSE CO. (MEADVILLE)	12 484	8000	PITTS BIT. 12 652	CRUSHER	3,03	3,03	MILL DRYING	IMPACT CENT-SYS	1	10	MOTOR 125 H.P.	——	TURB.	3	WATER	70	MILL	300	30	BRNR.	300	SLUICE	STM. JET
CROCKER BURBANK	5281	3450	POCAHONTAS 14 600	CRUSHER	4-0	4-0	MILL DRYING	AIR SWEPT	1	3	MOTOR 17 KW-HR/T.	80 THRO 100 MESH	STRAIT LINE	2	WATER	20	MILL	250	80	FRONT WALL	70	VAC. SYSTEM	——
MIAMI COPPER CO	7596	4200	DUBBS RESIDUUM 18000	——	—	—	——	——	—	—	——	——	MECH. AT	5	W.C. SIDEWALLS	ALL AT BURNR AT 410 DEG.							——	——

* BOILER SURFACE PLUS TOT. WATER WALL SURFACE.
Δ U.S. = UNIT SYSTEM C.S. = CENTRAL SYSTEM

STOKER EQUIPMENT

NAME OF STATION	* HEATING SURFACE SQ. FT. EA.	FURNACE VOLUME CU. FT. EA.	METHOD OF COOLING FURNACE WALLS	FUELS: KIND & B.T.U.	FUELS: PREPARATION	FUELS: % MOISTURE INITIAL	STOKERS: TYPE	STOKERS: LB. COAL PER SQ. FT. PER HR.	STOKERS: RATIO G-H-S GRATE	STOKERS: PROJECTED GRATE AREA	STOKERS: DRIVE	STOKERS: NO. RETORTS U.F.	STOKERS: NO. PIERS U.F.	STOKERS: CHAIN GRATE LENGTH-WIDTH IN FEET	AIR SUPPLY: ZONE CONTROL? IF SO NO. ZONES	AIR SUPPLY: AIR FOR COMB. PRESS INCHES H_2O	AIR SUPPLY: AIR FOR COMB. TEMP °F.	AIR SUPPLY: OVERFIRE CORR RATIO	AIR SUPPLY: OVERFIRE % TOTAL	AIR SUPPLY: OVERFIRE SOURCE	AIR SUPPLY: OVERFIRE PRESS IN H_2O	AIR SUPPLY: OVERFIRE TEMP °F.	ARE CLINKERS FORMED UNDER LED?	ASH DISPOSAL: FROM FURNACE	ASH DISPOSAL: FROM FLUE GAS
DELRAY #3	27 780	13 800	WATER	KENTUCKY 13 900	BREAKER	4	UNDER FEED	58	46.0	604	VAR-SP. D.C. MTR.	15	57	——	6 ZNS 15 SEC WIDE	12.5	350	——	INFILTRATION FROM ROOM				YES	CG TO HOPPER	HOPPER TO ASHPIT
OHIO RIVER	12 340	5800	WATER	INDIANA 11 000	CRUSHER	——	UNDER FEED	52	35.8	345	ST-TURB	12	35	——	——	5	100	——					YES TURB DRIVE		
ENGLISH ADD.	15 112	3080	AIR	BIT. 14 000	CRUSHER	2.75	UNDER FEED	45	57.0	285.7	ST-ENG	13	25	——	NO	5	ROOM	——	NEG	F.D. DUCT	VARIES		NO	AG TO TRUCK TO SKIP TO BUNK	HOPPER TO TRUCK TO S-H. TO BUNK
N-S-C & C.	5110	1818	NONE	COKE BR. OR COAL	——	10 8	CHAIN GRATE	——	34.5	148.04	D.C. MOTOR	——	——	L-17'-0" W-8'-8"	YES 5	3.5	ATMO.	300	——	ROOM	——	——	NO	CG TO SLUICE	——
NEW HAVEN PULP & BD.	8419	4800	PARTLY W.COOLED	NEW RIV 14 400	SLACK OR CRUSHED	2.5 5.0	UNDER FEED	29	40.8	207.0	4 SPEED MOTOR	8	33	——	NO	1.5	100	300	SOME THROUGH PERF. BLOCKS				YES	CHAIN & ELEV.	CRUTES TO CHAIN
HARRIMAN	5220	1800	NONE	TENN 13 500	CRUSHED TO 1/4"	3	UNDER FEED	30.5	47.3	110.5	D.C. MOT.	5	——	——	YES 3	5.0	100	300	——	WIND BOX	5	100	NO	CINDER HOPPER	MANUAL
FREMONT	1-8050 2-5000	1800 1200	NONE	KAN-11502 KL-11800	——	7.75	UNDER FEED	42 33 27	49.2 56.8 47.6	123 89 105	VAR-S-MOT ENGINE "	6 5 6	25 21 21	——	NO	1.75 2.0 2.0	225 70 70	225 200 200	—— —— ——	ROOM	0.05	—	NO	CARB. SKIP H.	CINDER CATCHER
AMERICAN BEMBERG	3 4040 3 6390	752.2 1356.6	NONE	VA. 13 300	CRUSHER	——	UNDER FEED	38.8 35.0	48.5 47.5	83.5 135.5	ST-ENG-ST-TURB.	5 7	18 24	——	——	6.0	ATMO.	——	——				NO	GATES TO TRUCKS	MANUAL
CHAMPION INTERN.	5598	2600	W.C. BRIDGE WALL	NEW RIVR 14 500	CRUSHER	2.5	UNDER FEED	58.0	45.1	124	4 SPD MOT. & TURB.	5	33	——	NO	6	390	300	——				NO	HOPPER TO CAR	——
AMERICAN GLANZSTOFF	8343	2325	NONE	VA. 13 500	CRUSHER	8	UNDER FEED	50	48.0	157.8	TURB. & MULT. SP. MOTOR	8	——	——	YES 2	8	80	200	0.15	F.D. DUCT	2	80	NO	DUMP TO HOPPER	SOOT TRAP
ST. PAUL'S SCHOOL	3000	1150	NONE	——	CRUSHER	——	SINGLE RETORT	——	——	——	STEAM CYL.	——	——	——	——	——	——	ROOM	——	——	——	——	NO	ASH HOPPER	——

* BOILER SURFACE PLUS TOTAL W.W. SURFACE.

At East River, with the central system the air for mill drying is from a separate steam air heater; primary combustion air put in at the burner is at 432 deg. from the regular flue-gas preheater. At Holland, also using the central system, primary air at 350 deg. is introduced below the feeder with secondary and tertiary air at the burners. Primary air temperatures with unit systems are shown a little lower than this, ranging between 200 and 300 deg.

Proportions of Combustion Air at Pulverizing Mills

In most cases, 15 to 25 per cent of the air for combustion is introduced at the pulverizing mill, in the case of unit systems, or ahead of the burner with central systems. The remaining air, from 85 to 70 per cent, is usually introduced at the turbulent burners. At East River it is introduced through the furnace side walls. Two important exceptions are noted on these tables: Cahokia with 60 per cent of the air at 235 deg. introduced at the mill and the remaining 40 per cent at 235 deg. at the burner; Meadville plant of the Viscose Co. with 70 per cent of the air at 300 deg. put in at the mill and the remainder at the burners.

Oil and gas burning equipment shows little change during the past year. Miami Copper Co. installation exemplifies the latest practice in oil-burning industrial boilers. Station A, the 1200-lb. installation at San Francisco, embodies the latest practice in burning both oil and gas. It is noteworthy that in both cases water-cooled walls are used.

Ash Disposal

Dissemination of ash dust to the atmosphere is a problem that is still of considerable concern to some pulverized coal plants, although to others it may be of minor importance because of their location away from towns. At State Line, three types of dust removers are now installed to clean the flue gas and a fourth type will be installed later. Electrostatic precipitators have been installed at East River on the new 800,000-lb. boilers described in the tables.

In the pulverized coal plants tabulated, removal of ash is mostly by sluice. Three of these plants use slag tap furnaces, as will be described later. In the stoker-fired, plants tabulated, mechanical methods of ash-handling predominate.

Two steel plants have recently completed power plants incorporating unique features, not shown on the tabulations. One of these, the Gulf States Steel Co. plant, was described in full in the Dec. 1, 1929 issue of Power Plant Engineering. In both cases, blast furnace gas is the principal fuel, supplemented by pulverized coal. As the supply of blast furnace gas varies with the operation of the blast furnaces, a combustion control system turns on pulverized coal burners fed from a central system and turns off gas burners, or the reverse, to supply the proper amount of steam. The boiler furnaces are of air-cooled refractory construction.

Rapid Condenser Tube Cleaning

Commonwealth Edison Co. has a difficult problem in cleaning condenser tubes in one plant where an extremely hard silica scale forms on the insides of the tubes. In each condenser are 13,300 brass tubes, 0.902 in. diameter by 18 ft. long.

Sand blasting and wire brushes were tried but best results came from a high-speed steel reamer on the end of a 20-ft. hollow, motor-driven shaft, with water fed through to wash away the scale chips. After reaming 60 tubes with the steel, it was necessary to regrind the reamer and 0.01 in. was worn off the blades, so that scale 0.01 in. thick was left on the tubes. Also a number of tubes would be split during the reaming.

One of the Commonwealth Edison Co. engineers, when Carboloy was announced, designed a reamer with blades having that metal on the tips, which has made it possible to clean 400 tubes before grinding with a reamer blade wear of 0.001 in. per 100 tubes as against 0.017 in. for high-speed steel. Besides more uniform and thorough cleaning, this has made possible cleaning of 1500 tubes a day by three men as against 750 a day with steel reamers and an entire condenser has been cleaned without a split tube.

Some enclosed engines and compressors are self-oiling as far as the crosshead, connecting rod and main bearing is concerned. In these cases, oil is maintained at such a level in the bottom of the crank case that the crank disc dips into it each revolution and while rotating throws the oil into the crosshead and into collecting pockets from which it is fed to the bearings. The oil then draws back to the crank case by gravity and is used again.

Progress in Furnace Design

TRENDS IN WATER-COOLED WALLS, HEAT RELEASE, SLAG-TAP FURNACES, FANS AND AIR PREHEATERS

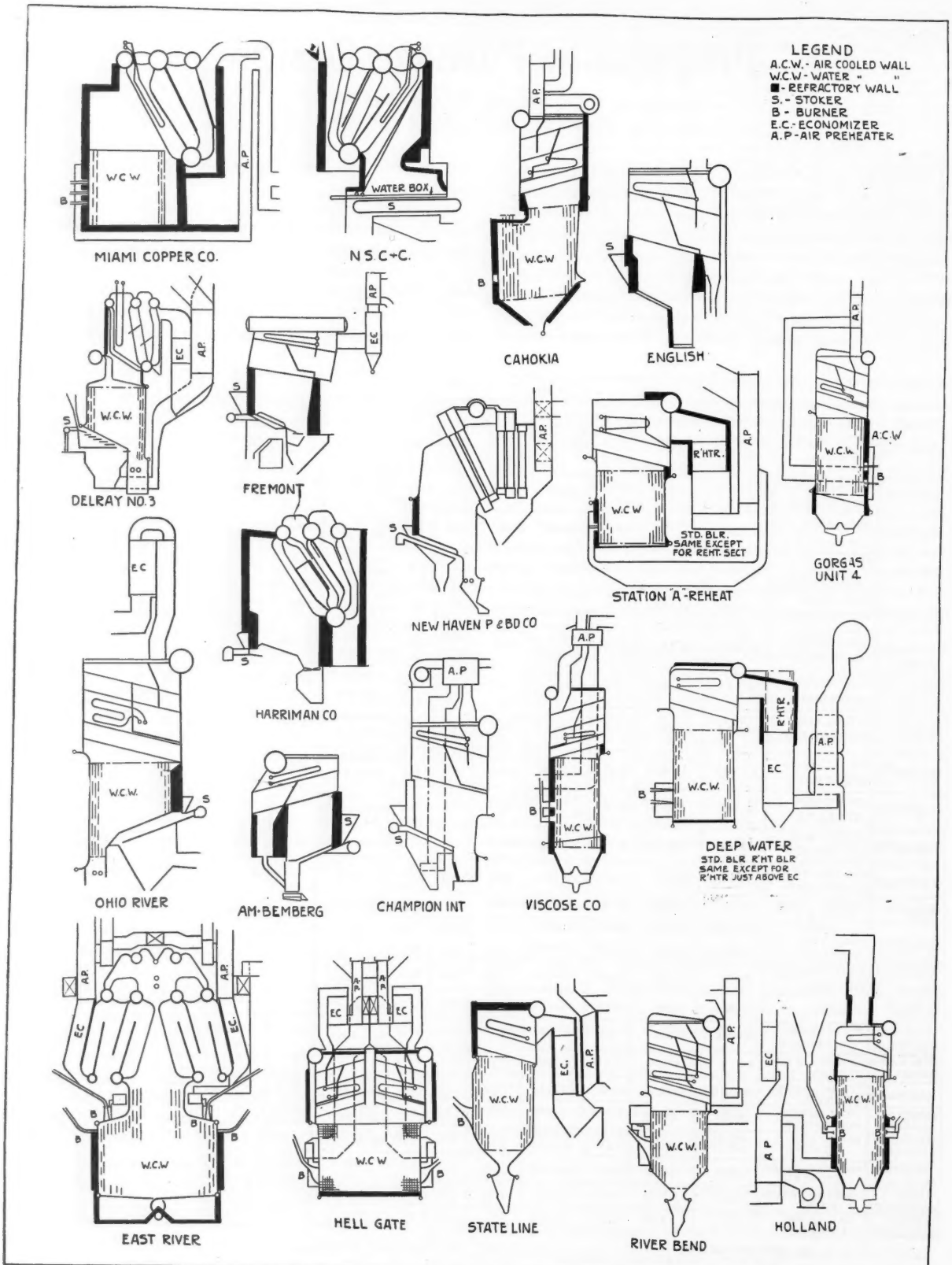
TRENDS in the method of combustion and in furnace design that were probable two years ago have been rather conclusively confirmed this year. Attention has been called to these trends in previous yearly analyses. The most important of these noted in the December 15, 1928 review were: increasing amounts of water-cooled furnace surface, especially with stokers, frequent use of variable inlet or vane control fans and further applications of the slag-tapping furnace. These same trends seem to be the most definite as shown by the tabulations this year.

Instances of water-cooling of practically the entire furnace wall surface of large boilers, to the virtual exclusion or absence of other types of walls, are typified by some of the central stations listed. This applies to stoker-fired furnaces such as Delray and Ohio River, as well as to pulverized coal furnaces. In the industrial plants noted; the trend is no less pronounced, although

FURNACE DESIGN

NAME OF STATION	FUEL AND METHOD OF FIRING	HEATING SURFACE* SQ. FT. EA.	FURNACE VOLUME CU. FT. EA.	RATIO FURN. VOL. TO B.H.P.	MAX. B.T.U. LIBERATED PER CU. FT.	CORRESPONDING BOILER RATING PERCENT	ARE ECON. USED?	ARE A.P. USED?	TYPE	WATER WALL SURFACE SQ. FT. PER BOILER	WATER WALL SURFACE PER CT. OF † TOTAL HTG. S.	WATER WALL SURFACE TYPE	FURNACE BOTTOM TYPE	FURNACE BOTTOM HEARTH SCREEN OR W.C. HOPPER SURF.
DEEPWATER	PITTS. 13,500 PULVERIZED	3 AT 11,502 3 " 11,139	19 080	1.65 1.71	22 640	——	YES	YES	WATER COOLED	3-2502 3-2139	21.8 19.2	COMB. OF BARE TUBES	SLAG TAP	NONE
HOLLAND	PENNA. #9 13 870 PULV.	10 122	16 500 ABVE. SCR.	1.63	20000	825	YES	YES	WATER C & REFRAC.	2194	21.7	FIN TUBES BARE " REFRACT.	HEARTH SCREEN	——
STATION A	OIL 18,500 GAS 1070 IN SUSPENSION	12316	15 100	1.23	43300	——	YES	YES	WATER COOLED	1617	13.0	REF. FACED BLOCKS ON TUBES	VENTILATD REFRACT'	——
HELL GATE 29 30	POC. 14000 PULVERIZED	56 898	45 100	0.795	24600 AT MAX LOAD	554	YES	YES	WATER COOLED	4590	8.07	TUBES COV. WITH REFRAC COV. BLOCKS	SLAG TAP	——
EAST RIVER ADD.	SEMI-BITUM. 14,000 PULV.	67 359	38 200	0.57	29400 MAX-LOAD	420	YES INTGL	YES	W. COOLED & S. REFRAC	7,345	10.9	FIN TUBES	HEARTH SCREEN	1290
STATE LINE	ILL. 10,200 PULVERIZED	14 735	22 500	1.53	——	——	YES	YES	WATER COOLED	4441	30.0	REF. COV'RD. TUBES & BARE BLOKS	SLAG TAP 5 W.C. HOP'R.	——
CAHOKIA	ILL. 10,800 PULVERIZED	19 836	14 650	0.74	19 800	400	NO	YES	WATER COOLED	1835	9.3	FIN TUBES & RECESSED PLAIN TUBE'	W. C. HOPPER	228
DELRAY #3	KY. 13500 STOKERS	27 780	13 800	0.50	33 000	——	YES	YES	WATER COOLED	3802	13.7	REF. BLOCKS ON TUBES	W.C. HOPPER	——
OHIO RIVER	IND. 11000 STOKERS	12 340	5600	0.45	ABOUT 35 000	——	YES	NO	W. COOLED SIDES & REAR	820	6.6	BARE TUBES WITH BLOCK AT FIRE LINE	CLINK. GR. & ASH HOPPER	——
GORGAS #2	ALA. 11 800 PULVERIZED	33 805	24 000	0.71	22 500	500	NO	YES	W. COOLED	3505	10.4	FIN TUBE	H'RTH. SCR. AIR COOLED ASH HOP'R.	H.S. 525
RIVERBEND	W. VA. KY. TENN. 13 200 PULV.	38 852	19 950	0.51	29 850	400	NO	YES	W. COOLED	3352	8.63	BARE C.I. BLOCKS ON TUBES	W. C. HOPPER	——
ENGLISH ADD.	BITUM. 14000 STOKERS	15 112	3060	0.203	54600	250	NO	NO	AIR COOL'D	——	——	——	ASH HOP'R.	——
FREMONT	ILL. 11 800 KAN. 11 500 STOKERS	1-6050 2-5000	1800 1200	0.27 0.22	37 500 27 500	300 200	YES NO	YES NO	REFRAC.	—— NONE ——		——	——	——
WAUKEGAN N.S.C. & C.C.	COKE BREEZE (OR COAL)	5110	1816	0.355	——	250	NO	NO	SOLID REFRAC.	——				——
ST PAULS SCHOOL	COAL	3000	1150	038	——	250 MAX	NO	NO	SOLID REFRACTOR	——	——	——	ASH HOP'R.	——
VISCOSE CO MEADVILLE	PITT. 12682 PULVERIZED	12 484	8000	0.64	25 000	500	NO	YES	W.C. BK. & SIDE REF. FRONT	2007	16.6	TUBES & FIREBRICK	HRTH-SCR. & ASH HOP'R	
NEW HAVEN P. & BD. CO.	NEW RIV. 14 400 STOKER	8419	4800	0.57	18 000	370	YES	YES	†††	824	9.8	†*	——	——
HARRIMAN	TENN. 13 500 STOKER	5220	1800	0.35	42 000	300	NO	NO	SOLID REFRAC.	NONE	——	——	ASH PIT	——
CROCKER BURBANK	POC. 14 600 PULVERIZED	5281	3450	0 65	25000	400	YES	NO	WATER COOLED	3680	7.0	BARE TUBE	CARB. TILE AIR COOLED	
AMERICAN BEMBERG	VA. 13,300 STOKERS	4040 6390	752 1356	0.186 021	54000 47000	200 200	NO	NO	SOLID ▲ REFRACTOR	NONE	——	——	ASH HOPPER	——
CHAMPION INTENATL	N. RIVER 14500 STOKERS	5596	2800	0.47	40 000	320	NO	YES	**	76	1,35	C.I. BLOCK	HOPPER	
MIAMI COPPER CO	DUBB RESIDUUM 18 000	7596	4200	0.55	17000	250	NO	YES	W.C. S. WALLS REST REF.	396	5,2	FIN TUBE	FLAT REF.	
AMER. GLANZSTOF	VA. 13,500 STOKERS	8343	2325	0 28	46500	25	NO	NO	++	——	NONE	——	HOPPER	——

* BOILER SURFACE
— PLUS TOTAL WATER WALL SURFACE
† TOTAL SURFACE AS IN COL. 3
▲ WATER SPRAY ON BRIDGE WALL AIR COOLED BRICK AT CLINKER LINE
††† FR. WALL BR. WALL & ARCH WATER COOLED. PERF. BLOCKS IN SIDE WALL
†* PROTECTED TUBES ON BRIDGE WALL. FR. WALL & ARCH BARE TUBES
** SOLID REFRACTORY AIR COOLED BRICK WALL
—++ SOLID REFRACTORY CARB BR. WALL. WATER SPRAY ON BR. WALL.



DIAGRAMMATIC CROSS-SECTIONS OF BOILER INSTALLATIONS INCLUDED IN THIS ANALYSIS, SHOWING GENERAL FURNACE ARRANGEMENT, FUEL BURNING EQUIPMENT AND RELATIVE POSITIONS OF ECONOMIZERS AND AIR PREHEATERS

AIR PREHEATERS

	NAME OF STATION	HEATING SURFACE SQ. FT. *	TYPE OF AIR H	NO. PER BLR.	HEATING SURFACE SQ. FT. EACH	HEATING SURFACE SQ. FT. TOTAL	CAP. LB. AIR PER HR. EACH	CAP. LB. AIR PER HR. TOTAL	AIR TEMP. IN	AIR TEMP. OUT	GAS TEMP. IN	GAS TEMP. OUT
CENTRAL STATIONS	DEEPWATER	3-11502 3-11139	PLATE	1	57,046 600 RED-52800	46,600 52,600	270,000 300,000	270,000 300,000	80 80	458 458	630 623	325 324
	HOLLAND	10 122	PLATE	2 SEC-IN 11 WITH 9 IN EA SERIES	———	32 450	———	252 000	70	405	582	336
	STATION A	RH 12316 STD "	TUBULAR "	1 1	51 806 46915	——— ———	548 000 454 000	——— ———	80 80	470 474	683 687	359 360
	HELL GATE	56 896	TUBULAR	2	30 250	60 500	466 500	933 000	70	304	497	313
	EAST RIVER	67 359	PLATE	2	45864	91 728	560 000	1120 000	70	432	665	398
	STATE LINE	14 735	TUBULAR	1	56 401	———	458 200	———	70	520	———	333 350
	CAHOKIA	19 836	PLATE	1	11 700	———	330 008	———	80	275	545	363
	DEL RAY *3	27 780	TUBULAR	2	14 895	29 790	209 450	418 900	70	350	535	350
	OHIO RIVER	———	———	———	———	———	NONE INSTALLED	———	———	———	———	420
	GORGAS *2	33 805	PLATE	1	30600	———	393 000	———	90	430	575	340
	RIVERBEND	38 852	TUBULAR	1	55 983	———	408 000 NORMAL	———	70	482	645	333
	ENGLISH	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	FREMONT	6050	PLATE	1	2478	———	———	———	100	225	381	250
INDUSTRIAL PLANTS	N.S.C.&C. CO.	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	ST PAUL SCH	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	VISCOSE CO MEADVILLE	12 484	ROTARY ELEMENT	1	18 090	———	AT 300% RATING	173 000	100	528	640	370
	NEWHAVEN	8419	PLATE	1	6600	———	80 000 100000 MAX.	———	115	240	442	277
	HARRIMAN	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	AM. BEMBERG	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	CROCKER BRBK	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———
	CHAMPION INTERNATL	5396	ROTARY ELEMENT	1	10 000	———	92 000	———	80	390	725	445
	MIAMI COPPER	7396	PLATE	1	7950	———	51 000	———	70	440	630	345
	AMGLANZSTOF	———	———	———	———	———	NONE INSTALLED	———	———	———	———	———

* BOILER SURFACE PLUS TOTAL WATER WALL SURFACE

where steam loads are steady and no high peaks are encountered, the necessity for cooling in industrial units is not so urgent, although for other reasons it may be of advantage.

Water-Cooled Walls with Stokers

Bridge walls cooled by water spray, as at the Bemberg and Glanzstoff plants, have effectively prevented clinker formation; air-cooled brick on the clinker line of stokers are often used. In industrial plants using pulverized coal, the water-cooled metal wall is generally used; following the usual central station practice.

With traveling grates, of which the only example tabulated is the North Shore Coke & Chemical Co., metal water-cooled furnaces do not seem to have such broad application, although they have been used in several important plants. The most important stations employing them at present are Crawford, Philo, Stanton and Aurora.

Proportions of Furnaces in Relation to Boiler

Study of several of the larger boiler units discloses some facts that may or may not indicate a new development in furnace and boiler construction. It will be noted that at Deepwater, Holland and State Line, all burning pulverized coal, the ratio of cubic feet of furnace volume to square feet of boiler heating surface is, respectively: 1.65 and 1.71, 1.63 and 1.53. Now, in connection with these ratios it should be noted that the water-cooled furnace wall surface in these cases is respectively 21.8, 19.2, 21.7 and 30.0 per cent of the total steam making surface (boiler surface plus furnace water wall surface). In short, about one fifth to one third of the surface making steam is in the furnace walls. The heat release at Deepwater is 22,640 B.t.u. per cu. ft. per hr., while that at Holland is 20,000, which are conservative values in comparison with some of the others tabulated.

At Station A the furnace volume to boiler surface ratio is 1.23 but the water wall surface is 13.0 per cent of the total. Other comparatively high values are 13.7 per cent at Delray using stokers, with a furnace to boiler ratio of only 0.50 and at the Meadville plant burning pulverized coal where the water wall surface is 16.6 per cent of the total with a furnace volume to boiler surface ratio of 0.64.

Other ratios of furnace volume to boiler surface for the pulverized coal plants range from 0.57 to 0.79. For the stoker fired plants these ratios are somewhat lower, ranging from 0.18 to about 0.50 in the central stations, the value of 0.57 for the New Haven Pulp & Board Co. being unusually high for the industrial plants shown. Corresponding percentages of water-cooled wall surfaces in the remainder of the plants noted on the tables range from 1.35 to 10, most of them being between 6 and 10.

Heat Release

Values for heat release in the pulverized coal plants show somewhat lower than those for stoker-fired plants. This is probably accounted for by the larger furnace volumes used to get more surface in the furnace walls and to handle the larger volumes of gas at peak loads. Values for the powdered coal plants are between 20,000 and 30,000 B.t.u. per cu. ft. per hr., the average being somewhat higher than that of last year. For the stokers these values range from 33,000 at Delray to 54,000 at English and American Bemberg.

Furnaces for use with 15-retort, 57-tuyere underfeed stokers at Delray are among the most interesting shown. The water-cooling tubes of the furnace walls constitute a screen boiler, the circulation of which is entirely separate from that of the main boiler.

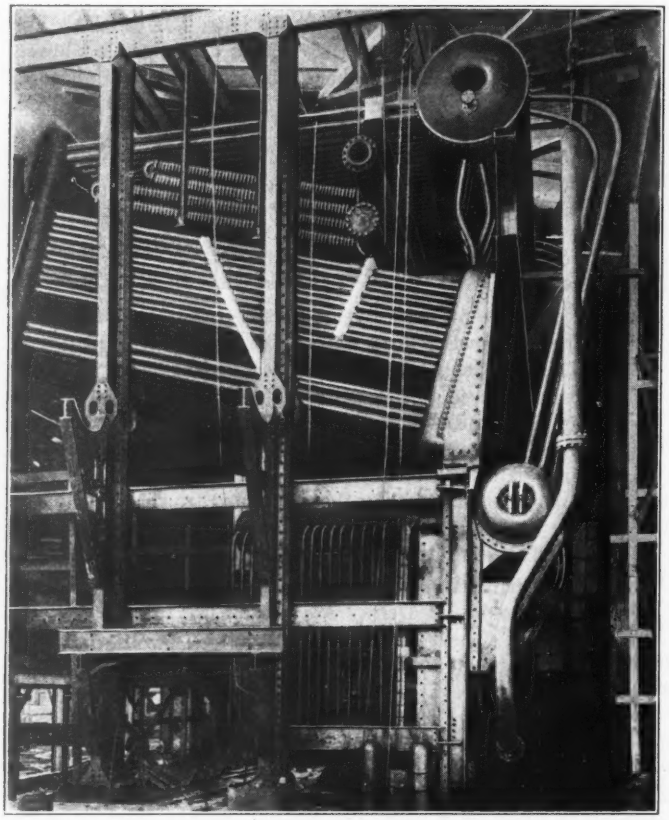
Slag tap furnaces are used on all the boilers at Deepwater and on the new 800,000-lb. units at Hell Gate. One boiler at State Line is also equipped with this type of furnace. Other pulverized coal stations employ the water-cooled hopper construction, as at Cahokia, State Line and Riverbend, while still others use hearth screens as at East River, Meadville, Gorgas.

Air preheaters of plate and tubular types predominate in the stations analyzed. A horizontal shaft model of the rotary element type preheater, the element revolving in a vertical plane, has just been announced.

FANS

NAME OF STATION	FORCED DRAFT TYPE	FORCED DRAFT NO. PER BLR.	FORCED DRAFT CAP. EACH C.F.M.	FORCED DRAFT CAP. TOTAL	FORCED DRAFT DRIVE	FORCED DRAFT STATIC PRESS. INCHES H_2O	INDUCED DRAFT TYPE	INDUCED DRAFT NO. PER BLR.	INDUCED DRAFT CAP. EACH C.F.M.	INDUCED DRAFT CAP. TOTAL	INDUCED DRAFT DRIVE	INDUCED DRAFT STATIC PRESS. INCHES H_2O	CHIMNEYS NO. SIZE PER CHIMNEY & HEIGHT
DEEPWATER	TURBO-V VANE CON	1	75,000	———	2 SPEED SQ-CAGE	10-0	TURBO-V VANE CON	1	130,000	130,000 AT 325°	2 SPEED SQ-CAGE	13-0	2-100
HOLLAND	TURBO-V VANE C-	1	78,500	———	2 SQ-CAGE MOT. 860 & 1170 R.P.M.	15-0	TURBO-V VANE C-	1	153,000	———	2 SQ-CAGE MOTORS	17-0	2
STATION A	VANE CNT	1	185000 REHEAT 125000 STD-	———	2 SQ CAGE MOTORS EACH	18-0	VANE CONTROL	1	280000 REHEAT 240 000 STD-	———	2 SQ. CAGE MOTORS EACH	15-0 R.H. 11-0 ST.D	4-200
HELL GATE 29-30	DOUBLE WIDTH DOUBLE INLET	2 *	150,000	300,000	ST-TURB	11-5	DOUBLE WIDTH DOUBLE INLET	4	125,000	500,000	ST-TURB	17-0	2-253
EAST RIVER ADD.	PRIMARY FOR BLWR	4 FOR 3 BLR	54,000	216,000	ST-TURB	23-0	DOUBLE WIDTH DOUBLE INLET	2	260 000	520000	ST-TURB	17-0	3-267'-6"
	SECONRY	2	190000	300 000	" "	9-0							
STATE LIN	VANE CONTROL	2	90,000	120,000	2 SPD- SQ CAGE MOT	7-5	VANE CONT ROL	2	110,000	220,000	2 SPD-SQ-CG MOT-	10-5	3-250
CAHOKIA	TURBO-V	2	32,500	65,000	2 SPEED IND-MOT-	11-0	MULTI-VANE	1	180,000	———	SLIP RING MOTOR	6-5	4-285
DELRAY *3	CONOIDAL DBLE-INL-	2	32,500	65,000	VAR-SPD-D.C.MOT	12-5	CONOIDAL DBL-INL-	1	223,000	———	VAR-SPEED D.C.MOT-	13-9	2-270
OHIO RIVER	AMER-N-S-	1	53,000	———	2 MOT-	5-0	SIROCCO NO-10	1	96,000	———	2 MOTORS	6-7	1- ———
GORGAS *2	TURBO-V-VANE CONTROL	1	166 000	———	SQ-CG MOT 695 R-P-M-	TO 14-0	TURBO V-VANE CONTROL	1	358000	———	2 CONST-SPD- IND- MOTOR	885 RPM 18-0 700 R.P.M. 12-0	2-30
RIVERBEND	TURBO-V-	1	128 000	———	CONST-SP S-C- MOT-	9-4	TURBO-V	1	26 2000	———	SQ-CAGE MOTOR	11-7	1-187
ENGLISH ADD.	TURBO-V-	1/2 ▲	150000	450 000	2 TURB-DRIVEN SQ-CAGE	5-0	NONE INSTALLED						3-217 △
FREMONT	VARIABLE INLET	1	23800	———	2 MOTORS 1 TURBINE	5-5	VARIABLE INLET	1	28500	———	MOTOR	———	70 150
WAUKEGAN N.S.C.&C. CO	TURBO CONOIDL VAR-OUTL	1	23 000	———	TURB-OR SQ-CAGE	2-5/24/ 4-5				NONE INSTALLED			2-225
ST. PAUL'S SCHOOL	FORCED DRAFT TURBINE BLOWER									NONE INSTALLED			3-125
VISCOSE CO MEADVILLE	TURBO-VANE	1	37000	———	MOTOR	10-0	DUPLEX CONOIDAL	1	110 000	———	MOTOR	———	1-172
NEW HAVEN P&BD CO	TURBO-VANE	1	23000	———	SLIP RING MOTOR	9-45	TURBO-VANE	1	35000	———	SLIP RING MOTOR	2-80	1-125
HARRIMAN	TURBO-V	1	21500	———	S.C.MOT R.	5-0	MULTIVANE	1 FOR 3 BLR	132 000	———	STD-TURB WITH REL. GEAR	3-25	3-150
CROCKER BURBANK				NONE INSTALLED				1	38000	———	SLIP RING MOTOR	9-25	1 200
AMERICAN BEMBERG	WAKE C. 2 FXD.INL.	1 2	34800	103.200	1 CS-MOT 1 CS-T-II (SECTURB)	8-9			NONE	INSTALLED			6-200
CHAMPION INTERNATL	TURBO-VANE	1	23300	———	TURBINE	7-5	TURBO-VANE	1	43300	———	TURBINE	5-0	3-150
MIAMI COPPER CO	RADIAL FLOW	1	18000	———	CONST SP. MOTOR	8-6	RADIAL FLOW	1	36000	———	CONST SPD. MOTOR	3-7	4-205
AMERICAN GLANZSTOF	VANE VAR-SP.	2 FOR 4 BLR	63000	190 000	1 IND-MOT 1 TURBINE	8-0				NONE			4-250

▲ 3 F.D. FANS INSTALLED. 2 BEING INSTALLED, 1 FUTURE.
△ 2 CHIMNEYS " 1 " " 1 " .
‡ SPEED CONTROL THRO. CHRONOMETER VALVES OPER. FROM COMB. CONT. SYSTEM.



Use of Large Size Boilers Increases

Increase in Number of High Pressure Stations and of Plants Serving High-Pressure Exhaust Steam for Industrial Purposes. Temperatures, Due to Lack of Proper Materials Seem Fixed at 750 Deg. Alloy Steels Substituted for Carbon Steels Reduce Deterioration. More Intense Study of Possible Materials for Boiler Drums, Headers and Tubes and of Boiler Problem Is Desirable. High Temperatures Give Promise of Thermal and Economic Gains. Standardization of Materials and Processes Mark Boiler Development.

TENDENCIES in the use of the heat absorption media of power plants during the past year have been more in the direction of consolidating the gains incident to past progress and to raising the average standard of design and operation, than to developments of new or radical departures from established practice. High pressures and high superheat already had been reached and high economies established. The Columbia station, a medium high pressure plant operating at 650 lb., had reported a sendout rate of 12,500 B.t.u. per kw. The Mercury vapor boiler has operated on a fuel economy of 10,000 B.t.u. per kw. One of our latest stations—Deepwater—was designed to consume not more than 9450 B.t.u. per kw. at the turbine-generator, when operating at 53,000 kw.

High Pressures Become More Popular

Equipment is now available for operation at steam pressures over 1400 lb. per sq. in. abs. and steam temperatures of 750 deg. are now employed. Equipment is also available for the reheating of steam bled from the lower stages of steam turbines, using either the heat from flue gases or the latent heat from high pressure steam for that purpose and means are available for heating feedwater by use of the regenerative cycle, employing as many as five stages of heating for this purpose. By means of economizers and air preheaters, which are now available even at reasonable cost, losses in flue gases may be reduced to very low values and boiler units having capacities capable of developing 20,000 kw., employing the mercury-vapor-steam cycle, are now available.

While only two of the stations investigated—Deepwater and Holland—report the production of 1400-lb. steam, a third, Station A in San Francisco, closely approximating this high figure, the general trend in central stations is toward use of higher pressure steam. This is evidenced by the rapid acceptance as economical and practical of the 1200-lb. cycle with reheat. At present, the lowest pressure that appears to justify the additional expense of reheating equipment is 600 lb.

Steam Temperatures Not Increasing Materially

Steam temperatures have not kept pace with steam pressures. Temperatures of from 650 to 700 deg. F. have been common with 300 and 400-lb. boilers whereas 750 to 775 deg. F. seems to be about the practical limit for present installations of from 1200 to 1400-lb., in this country. The probable reason for this limitation is the failure of materials, economically available, to withstand higher heat.

Temperature Limitation Due to Material Failure

Results from both short-time tensile and long-time creep tests, made by Professors White and Clark, show the limitations of plain carbon steels, especially at temperatures much above 750 deg. F. Short-time tensile tests conducted on a 0.13-per cent carbon steel show the tensile strength to fall off rapidly at temperatures above 500 deg. while the same is true of the proportional limit at temperatures above 750 deg. Many will await with interest the outcome of the experiments being conducted on the 1000-degree installation at the Detroit Edison Co. plant.

BOILER DATA

	NAME OF STATION	NO	TYPE	CAP. PER BLR – THOUSAND LB. PER HR. NORM'L	CAP. PER BLR – THOUSAND LB. PER HR. MAX.	HEATING SURFACE PER BOILER – BOILER SQ. FT. B.H.S.	WATER WALL-W.W. SQ. FT. **	WATER WALL-W.W. % O.H.S	SUPERHTR SQ. FT.	SUPERHTR % O.H.S	ECONOMIZER SQ. FT.	ECONOMIZER % O.H.S	AIR PREHTR SQ. FT.	ABS. PRESS. LB. SQ. IN.	NO PASSES	FURNACE VOL. CUBIC FEET	FURNACE VOL. CU FT PER C.H.S.	SOOT BLOW METH'D	TUBES ELE. PER BLR	TUBES DIA. IN.	TUBES THICK B.W.G	TUBE B'NK WIDE	TUBE B'NK HIGH	SLAG SCRE'N ?	DRUMS NO	DRUMS TYPE	DRUMS STEAM DIA.	DRUMS STEAM LENGTH
CENTRAL STATIONS	DEEPWATER	4S ③ 2R	CROSS DRUM	250000	331000 S ③ 290000 R	6-9000	3 AT 2502 3 AT 2139	21·8 19·2	——	——	18326-S ③ 4765-R	2·59 2·165 1·41·5 1·428	46 600-S 52 800-R	1415	1	19 080	3 AT 1·66 3 AT 1·71	STEAM MANUAL	14	3¼	0	53	8	NO	1	CROSS	60	50'—3"
	HOLLAND	2	STRAIT TUBE	250 000	300 000	2–7928	2194	21·7	5500	54·2	11 880	11·8	32450	1400	1	16 500 ABOVE WATER SCR·	1·65	AIR MANUAL·	—	3¼	0	46	8	YES	1	"	52	46'-0"
	STATION A	1-S 2-R	HORIZ·	250 000-S 350 000R	500000	10 699	1617	4·06 4·5R	7430-S 6300-R	18 17	20944-S 17795-R	51·5 49	46915-S 51 606-R	1350	1	15 100	1,22	——	—	3¼	——	62	8	NO	1	"	80	51'-0"
	HELL GATE '29-'30	2	CROSS DRUM TWIN	500 000	800000	2–52306	4590	8·07	——	——	16 600	29,2	60 500	300	3	45 100	0795	STM·MAN·	48	4	6	58 X 18 EACH	58 X 18 FOR HALF	YES·SLAG ④	2	"	72	43'-0"
	EAST RIVER ADD·	3	VERT BENT TUBE DBL·SET	533000	800000	3-60 014	7345	10·9	13900	20·6	——	——	91 728	390	4	38 200	0.57	"	28	3	8	36 X 7 43 X 25 PER SECT·		YES	10	"	54	30'—1/12" 37'-7 1/2"
	STATE LINE	6	HOR·	——	450	10 294	4441	30·1	7200	48,8	19820	134·5	56401	650	1	22 500	1·53	STEAM	—	—	—	——	——	——	—	"	——	——
	CAHOKIA	2	"	130 000	200000	2–18010	1835	7·7	4070	17	——	——	11 700	350	3	14 650	0.839	STM·MAN·	18	4	10	38	20	NO	1	"	60	31'-7"
	DELRAY #3	5	INCLIN·	——	340 000	3-23978	3802	13·7	4900	17·7	6032	21·7	29790	409	4	13 800	0,498	"	18	3¼	7	53	22 ⑤	YES	4	"	1-42 3-48	28'-0"
	OHIO RIVER	2	CROSS DRUM	120 000	140000	2-11,520	820	6,56	2150	1745	8640	70	NONE	——	3	5600	3,98	STEAM	—	4	6	36	13	"	1	"	54	30'-3"
	GORGAS #2	2	CROSS DRUM	350000	500000	2–30300	3505	9	4991	12·9	NONE		30 600	475	3	24 000	0·71	AUTO STEAM	12	4	6	51	20	"	1	"	72	34'-3"
	RIVERBEND	4	HORIZ·	400 000	450000	4–35 500	3352	8·6	6600	17	NONE		55 983	465	3	19 950	0,514	STEAM	24	4	5	51	24	"	1	"	72	34'—0"
	ENGLISH	12	"	52 100	130000	15112	—NONE—		⑥	⑥	——	NONE	——	400	3	3060	0,203	STEAM MANUAL	6	4	7	39	16	NO	1	"	54	24'—1"
	FREMONT	2 1	" INCLIN·	1-18000 1-15000 "	54 000 30 000 "	6080 5000 "	— NONE	—	1782 1500 "	29·7	864 NONE "	1,44 ——	2478 —— ——	335 235 "	3 3 3	1600 1200 "	0,248	STEAM	6 5 5	3½ 4 3½	——	19 16 22	17 15	NO	2 2 4	LONG " CROSS	37 34 24,8 24,32	——
INDUSTRIAL PLANTS	WAUKEGAN N.S.C.& C.CO.	2	HOR	——	——	2–5110	——	——	384	7·5	——	——	——	250	3	1816	0·355	STEAM MANUAL	8	3¼	10	20	16	NO	4	"	36	13'-2 1/2"
	ST. PAUL'S SCHOOL	3	HOR·	——	——	——	——	——	——	——	——	——	——	185	—	——	——	——	——	——	——	——	——	——	1	LONG	48	18'—0"
	VISCOSE MEADVILLE	3	CROSS DRUM	90000	150000	10477	6507	38,4	1835	10·8	——	——	3-18090	465	3	8000	110	STEAM		4	6	24	18	YES	1	CROSS	54	20'-10"
	NEW HAVEN	1	VERT ST·TUBE	84000	72000	7595	824	8,24	NOT GIVEN		1639	18,4	6600	405	1	4800	048	"	8	3¼	8	6	5⑦	NO	1	"	48	18'-0"
	HARRIMAN	3	INCL·	40000	50000	5220	——	——	—— NONE		——	——	——	265	3	1800	0,348	MANUAL	6	1½	——	17	——	"	4	"	2-42 1-36	10'—4"
	CROCKER BURBANK	3	CROSS DRUM	44000	60000	3—4893	368	7·5	114	2,2	2511	47,8	——	420	3	3450	0,706	STEAM	5	4	6	17	15	"	1	"	54	16'-5 1/4"
	AMERICAN BEMBERG	3 3	HOR· CROSS DRUM	24000 38000	36000 57000	3-4040 3-6390	—NONE—		3-238 3-376	7·1	——	NONE	——	272	3	3-752 3-1356	0,86 0,21	"	—	—	——	——	——	——	—	"	——	——
	MIAMI COPPER CO·	4	SEMI-VERT·	50000	63000	7200	396	5·2	1085	14·3	NONE		7950	435	3	4200 ⑥	0·55	STM·MAN·	5	3 2	8 11	20 30	7 15	NO	4	"	30 24 24 24	18'-1" 18'-1" 18'-1" 18'-1"
	AMERICAN GLAZSTOFF	4	INCL·	50000	75000	8343	— NONE—		——	——	——	NONE	——	265	3	——	——	MANUAL	—	3¼	8	——	——	"	3	"	42	18'-9 1/2"

* COMBINED H·S·= C·H·S·= B·H·S·+ W·W·+ INTEGRAL ECON· SURF·

** TOTAL SURFACE INCLUDING HEARTH SCREEN·

③ S=STANDARD· R = REHEAT·

④ SCREEN AT TOP FURNACE-NONE AT BOTTOM·

⑤ PLUS 1 WATER CIRCULATING & STM· CIRCULATING TUBES·

⑥ TEMP·SUPRHT· 150° F·ABOVE TEMP OF SATURATED STM· AT 200% RATING·

⑦ INCLUDING ECONOMIZER

Being urged by the following incentives, there is a definite desire on the part of operating and designing engineers to use temperatures above 750 deg. An increase in temperature will result in a material reduction in fuel consumption. If the increase in steam temperature can be effected without the adoption of radical changes in design, it is one of the easiest ways of effecting an appreciable fuel saving. An increase from 750 to 1000 deg. F. offers practically the same heat economy as one stage of reheating but with decidedly less complication.

Higher temperatures will also result in a reduction in the investment, assuming that no marked change has been made in the construction of the steam generating unit such as by use of expensive alloy metal and of single stage reheating with steam returned to the boiler. Increase in temperature at the turbine throttle with the corresponding reduction in the lower stages of the turbine results in very material reduction in the amount of erosion in the lower stages of the turbine, reducing the cost of one of the largest single items of turbine maintenance and increasing the yearly number of available hours of service.

Alloy Steel Now Employed

Use of alloy steels for high temperature duty is therefore now being made; however, alloying additions must be kept as low as possible in order to avoid excessive cost. Chromium-tungsten heat-treated steels appear to be among the most suitable for this purpose. Valve manufacturers are ready to guarantee equipment to operate with steam at 1000 deg. F.

The most serious obstacle standing in the way of more general adoption of higher temperatures is the fear that there will be a rapid deterioration in the superheater elements. Due to the transfer of heat through the wall of the superheater element, the metal temperature is appreciably higher than the steam temperature and it is the temperature of the metal which determines the rate of deterioration.

Another problem in this connection is that due to the transfer of heat through the wall of the superheater element, which causes the outer skin to be at a higher temperature than the inner portion of the wall, resulting in the setting up of temperature stresses which, under certain extreme conditions, may be of the same magnitude as the stresses from the steam pressure.

Temperature Gradient in Metal Reduces Life

Reduction of the differential between the maximum steam temperature and the maximum temperature of the metal will be beneficial. A decrease in the average rate of heat transfer and particularly in the rate of heat transfer at the outlet end of the superheater; an increase in the steam velocities through the elements; a reduction in the mean internal hydraulic radius of the superheater elements; the introduction of saturated steam into the portion of the superheater in contact with the hottest gases; the maintaining of high steam velocities in the elements and low steam velocities in the headers so as to insure uniform distribution of steam between all elements in parallel; the elimination of laning of the gases through the superheater and the elimination of secondary combustion in the superheater pass, are all effective in the reduction of the differential between the highest metal temperature and the steam temperature at the superheater outlet. A reduction in the maximum rate of heat transfer for any portion of the superheater and particularly for the area adjacent to the superheater outlet, will serve as a most effective means of reducing heat stresses. Developments along these lines may be, therefore, anticipated.

Pressure and Temperature Definitely Related

As the thermal advantage of increasing the initial steam pressure is definitely tied to the assumed maximum steam temperature it would appear that, until some rather radical departure from present high pressure practice is evolved, we have, at least for a time, reached a limiting practical operating pressure.

As pointed out by C. F. Hirshfeld, at any given assumed initial steam temperature, either with or without reheat, increasing the steam pressure from a low value causes a thermal saving but the rate of increase of this saving decreases as the pressure rises until finally a pressure is reached beyond which improvement is insignificantly small. This point moves up to higher pressure as the assumed initial temperature is increased.

In continental Europe, development has been directed more particularly toward higher temperatures and those efforts that have been directed toward higher pressures have been made along lines somewhat different than but equally characteristic of American tendencies. There, the engineers endeavored to analyze, in advance, all the new factors which might be expected to enter the problem and then to produce designs which would properly take account of these new factors. They anticipated certain difficulties as a result of such analyses.

Effects of High Temperature Production

Briefly, the principal considerations made were as follows: 1. As the pressure rises, the temperature also rises, therefore the temperature of the heat transferring metal in the boiler also rises. Thus difficulty in preventing the burning of such metallic surfaces in high pressure boilers was anticipated. 2. With the metal thus endangered, a very thin film of scale may be expected to threaten the life of the tube to the same degree as much thicker scale would at lower temperatures. 3. As the pressure rises, the specific volume of saturated steam decreases rapidly and the difference of density of steam and water in the boiler decreases, thus threatening the circulation in boilers of ordinary type in which density differences in different parts cause the "natural" circulation upon which we depend. 4. The latent heat of vaporization also decreases as the pressure rises, so that the anticipated decreased rate of circulation is accompanied by a phenomenon which tends to make each pound of water flowing over the heating surface, less effective as a heat remover. 5. The chemistry of boiler waters at high pressures and temperatures is practically unknown, so that many unsuspected opportunities for trouble may be hidden in high-pressure boilers of the ordinary type. 6. Finally, the cost of boiler drums of conventional design must increase rapidly unless the diameter is rapidly decreased as pressures rise. This brings in new problems with respect, both to steam freeing surface and to the thermal storage required to minimize pressure changes during sudden changes of steam demand.

Foreign Endeavors to Overcome Difficulties

In order to avoid operation difficulties under high pressure and temperature, some European designers and builders have resorted to more or less radical design, thus the inventor of the Atmos boiler adopted a rotating boiler tube with provision for most intimate forced contact between water and metal. The inventor of the Benson boiler made his boiler proper without drums or steam space. One of these boilers was designed for the Langebrugge generating plant of the Compagnie des Centrales Eletriques en Flandres in Belgian. This boiler is designed to produce 100 t. of steam per hour at a pressure of 3200 lb. per sq. in.

In the Schmidt unit, the high pressure boiler consists of two boilers operating at different pressures. The boiler operating at the higher pressure being filled with distilled water which functions in a closed system and hence serves merely as a heat transferring device and protects the surfaces exposed to the fire from the effects of scale deposition.

In the Loeffler system, steam which has been highly superheated, is blown into water in a simple drum and generates saturated steam from that water at the desired pressure. This steam is passed through a separately fired superheater equipped with air preheater and economizer to obtain high efficiency of the combustion part of the cycle and with a regenerator to obtain high efficiency of the prime mover. Part of the steam which is superheated goes to the prime mover and the remainder is returned to the water containing drum to keep up the production of saturated steam. A steam pump of some sort is necessary, however, to force the steam through the superheater.

With this system it is possible to overcome the objection of those who think that although a superheater may be built to furnish steam at 900 deg. superheat, such steam might be expected to cause trouble in the prime mover, because steam intended to be used in the prime mover could in the Loeffler system, if desired, be tapped off at some intermediate point in the superheating equipment.

More Intense Study of Boiler Problem Desirable

Other evolutionary and revolutionary suggestions and designs have been offered by foreign engineers while, in the United States, development has been without radical departure from established designs and with little or no special study of the European developments to discover their possibilities under the conditions prevailing here.

One notable effort in fundamental analysis which gives promise of wide application is the recent paper on "Analysis of Heat Absorption in Boilers and Superheaters" by N. Artsay, Trans. A. S. M. E. Fuels & Steam Division, Sept.-Dec. 1929, page 247, in which the author presents an easy method of calculating the heat absorbed in each boiler section, such as in each row of tubes. Efforts, in this country, have been directed more toward standardization in design and manufacture.

SUPERHEATER & ECONOMIZER DATA

NAME OF STATION	SUPERHEATERS								ECONOMIZERS							
	TYPE	HEAT SURF. PER SQ. FT.	HEAT SURF. PER % B.H.S.	ELEMENTS DIA. IN.	ELEMENTS B.W.G. NO.	TEMP. °F. SUPER HEAT	TEMP. °F. TOTAL	CORRES. BOILER RATING	TYPE	HEAT. SURF. SQ. FT.	HEAT. SURF. % B.H.S.	LOCATION	TEMP. WATER IN	TEMP. WATER OUT	TEMP. GAS IN	TEMP. GAS OUT
DEEPWATER	CONVECTION ABOVE DECK	———	———	2	4	142	725	———	STEAMING-S WATER-R ①	18326 S 4765 R ①	2-159 2-165 1-41·5 1-42·8	BACK OF BLR	430 430	STM. 450	——— 717	630 623
HOLLAND	CONVECTION ABOVE B-TUBE	5500	69·3	2	4	168	750	———	GAS-WATER	11880	150	"	431	522	875	582
STATION A	CON.	7430-S 6300-R	68·5S 59·0-R	2	4	178	750	———	STEAMING WATER	20944-S 17795-R	196 166	"	436	STM 546	1194	683
HELL GATE '29-'30	CONVECTION INTERDECK	——— INFORMATION NOT COMPLETE ———							EXTERNAL	16600	31.9	ABOVE BOILER	270	350	760	497
EAST RIVER ADD.	"	13900	20·8	1 7/8	10	257	700	———	INTEGRAL	———	———	———	———	———	———	———
STATE LINE	CON. ABOVE B TUBE	7200	70	—	—	———	750	———	STEEL LOOP COUNTERFLOW	19 820	193	BACK OF BOILER	—	—	—	—
CAHOKIA	INTERDECK	4070	22·6	2	10	290	750	250	NONE							—
DELRAY 3	CON.	4900	17·5	2	8	—	725	340,000LB PER HR	HORIZ. TUBE RET. BEND	6032	21·7	BACK OF BOILER	320	370	730	550
OHIO RIVER	INTERDECK	2156	18·7	—	—	245	690	120,000 LB. PER. HR.	WATER	8640	134	ABOVE BOILER	200	310	680	360
GORGAS #2	CONVECTION INTERDECK	4492	12·8	2	10	295	750	500	———		NONE	USED				—
RIVERBEND	CONVEC. INTERDECK	6600	18·6	2	8 6	—	750	———	———		NONE	USED				—
ENGLISH ADD	INTERDECK	——— ② ———		—	—	150	600	250	———		NONE	USED				—
FREMONT	CON. INTERDECK	1-1782 1-1500 "	29 30 "	2	8	150	550	220	WATER	864	1-44 NONE "	BACK OF BLR. NONE "	200 —	250 —	550 —	380 —
WAUKEGAN N.S.C.&C.CO.	CONVECT.	384	7·5	1	—	150	550	200	———							—
ST PAUL'S SCHOOL	——— NONE USED ———								———		NONE	USED				—
VISCOSE MEADVILLE	INTERDECK	1835	17·5	1	—	150	150	606·5	———							—
NEW HAVEN P & BD CO	INTERPASS	NOT GIVEN	———	—	—	160	600	250	INTEGRAL	1639	———	BACK OF BOILER	220	—	530	442
HARRIMAN	——— NONE USED ———								———		NONE	USED				—
CROCKER BURBANK	RADIANT	114	2-3	2 5/8	—	200	645	200	———	2511	52	ABOVE BOILER	214	308	615	338
AMERICAN BEMBERG	CONVECTION	3-238 3-376	5·8	1·75	—	135	537	175	———		NONE	USED				—
MIAMI COPPER	"	1085	15	1 5/8	10	200	850	250	———		NONE	USED				—
AMERICAN GLANZSTOFF	CONVECT. INTERDECK	———	———	—	—	200 300	600 700	150	———		NONE	USED				—

① S = STD. BOILER. R = REHEAT BOILER.
② TO SUPER HT. 150° F. ABOVE TEMP. OF SATURATED STEAM AT 200% RATING.

Manufacturers have perfected their shop processes and tools and have sought the use of better materials to aid them in increasing the upper limit of operating pressure for which equipment of fairly standard characteristics can be designed. Successive increases from 385 lb. to the present 600 lb. maximum allowable operating pressure for straight-tube, cross-drum boilers of fairly conventional design, using 4-in. dia. tubes have been made. At the present time, bent tube boilers having riveted drums and of fairly conventional design, can be purchased for an operating pressure of 450 lb. gage.

Inside Calking of Seams Widely Used

In connection with riveted drums, the practice of inside calking of seams has been adopted almost universally. The limitation in operating pressure for which bent tube boilers, having riveted drums, can be designed has mainly existed in connection with the drums and has served to limit the maximum pressure for a time to 410 lb. and more recently to 450 lb. With respect to straight-tube, cross-drum boilers, the limit in pressure has been in connection with the headers. In many cases, the practice adopted has been to design the drums for a pressure somewhat higher than that in the headers and tubes in order to allow for an appreciable amount of pitting in the drum without the necessity of derating the operating pressure of the boiler. One manufacturer supplies drums made of a single plate with but one riveted longitudinal joint.

RESUPERHEATERS

STATION	TYPE	NO. RE-SUPER-HEATERS	BLR. SRVD. BY REHEAT	BOILER NO	BOILER B-H-S.	BOILER PRS LB. ABS.	BOILER TYPE	BOILER TOTAL WHS. EACH BLR.	SUPERHEATER SECTION SURFACE/BLR. SQ. FT.	SUPERHEATER SECTION SURFACE/BLR. % W.H.S.	SUPERHEAT °F	TOTAL TEMP °F	REHEAT SEC. EACH BLR. PRESS LB. ABS.	REHEAT SEC. EACH BLR. TEMP. IN	REHEAT SEC. EACH BLR. TEMP. OUT	REHEAT SEC. EACH BLR. SURFACE SQ. FT.	REHEAT SEC. EACH BLR. SURFACE % W.H.S.	CAPACITY REGEN. % W.H.S.	CAPACITY LB/HR.	CAPACITY LB/HP
DEEPWATER	GAS	2	4	9000	1413	CROSS DRUM		34155	——	——	142	725	403	495	750	25506	280	73·8	[illegible]	11·6
HOLLAND	GAS & STEAM	1 G 1 S	4	7928	1400	STRT TUBE		20958	5500	69·3	188	750	100–415	—	—	[illegible]	185	62·3	[illegible]	19·2
STATION	GAS & STEAM	3 G 2-S	2	10699	1356	HORIZ CROSS DRUM		——	6300	59·0	178	750	390		750	—	—	—	—	—
STATE LINE	STEAM	2	8	10284	650	CROSS DRUM		885284	7200	70·0	252	750	115	404	489	—	—	—	[illegible]	—

* RATIO LB-HSQ.-FT.-: LB/HR.÷SQ FT REHEAT SURFACE.
** W.H.S.= B.H.S. + REHEAT SURFACE

Flat Gage Glasses Supersede Round for High Pressures

Adoption of operating pressures in excess of 400 lb. in such a large proportion of stations has involved the almost universal discarding of round gage glasses and the use of high-pressure gage glasses having flat-glass windows. The problem of illuminating the flat-glass windows has not been satisfactorily solved for most installations. A most valuable development, in this regard, has been the use of a standard recording flow meter, calibrated to record the head of water in the water column and therefore serving as an accessory to the high-pressure gage glass recording the level of water in the boiler drum.

Another characteristic objective sought in this country is reduction of investment, labor and maintenance unit costs. It has been found that an increase in pressure, as long as it is accompanied by no marked change in the characteristics of the equipment or the size of the steam generating units and of the turbine-generators, produces two results: a reduction in fuel consumption per kw-hr. of station send-out and a reduction in the investment per kw. of station send-out. A very definite trend, in connection with much of the recent steam station construction, is the use of highest pressure for which steam generating equipment of fairly standard characteristics can be purchased at the time of design.

Convection Type Superheaters Preferable

Referring to the table on Superheaters and Economizers, it will be seen that four plants reported using steam at a total temperature of 750 deg., two at 725 and three at 700. All but one employed a temperature above 500 deg. Superheaters used, appear to be predominantly of the convection type. Increased production by central stations of high-pressure exhaust steam for process work is also indicated. Two notable examples are among the plants investigated. At the American Bemberg plant, steam for process work is served at 125 lb. while at the Deepwater station large quantities of exhaust steam are supplied at 180 lb. press. to the adjacent Dupont plant. Before leaving the generating station, this steam is superheated to 440 deg. F. total temperature, by live steam superheaters taking steam at 1200 lb.

Greater popularity of the convection type of superheater is probably due to the fact that the high rates of heat transfer suffered by the radiant type of superheater which has elements of plain forged steel and thickness of walls of approximately ¾ in., result in relatively high metal temperatures and stresses. In contrast, the use of convection type superheaters, shielded from the furnace by 10 rows of boiler tubes and designed with very liberal areas, will permit, more readily, of delivering steam at a temperature of 800 deg. F. or higher and a maximum heat transfer rate of approximately 5000 B.t.u. per hr. per sq. ft. of surface.

Increasing proportion of superheater, as well as, air preheater surface to boiler heating surface will be noted by examination of the superheater table.

Following closely the increased use of high-pressure steam, we find increased use of stage bleeding, of number of bleed stages and use of reheaters. Four of the stations investigated report use of resuperheaters, whose heating surfaces range from 59 to 70 per cent of the boiler heating surface as shown in the table on Resuperheaters. Two of the plants—Holland and Station A—use both flue-gas and steam resuperheaters.

Combination Resuperheaters Used

In the Holland station, saturated steam from the boiler, is used in the steam resuperheater for supplying the heat and constant reheat temperature is obtained by thermostatic regulation of the steam flowing to the steam resuperheater, the proportions of the two resuperheaters being so arranged that at full load the steam resuperheater is nearly cut out while the flue gas resuperheater furnishes all the heat required. In the latter station, steam which has passed through the high-pressure turbine, is reheated before it enters the low-pressure unit, to 750 degrees.

At the State Line station, steam exhausted from the high-pressure element at 118 lb. almost to the saturation line, is divided between the two reheaters used and the No. 3 extraction heater which immediately precedes the boiler feed pumps.

Although only two of the stations investigated report use of steaming economizers, increased use of high-pressure steam may be expected to result in more extended use of such economizers.

Combination Treatment Methods Prevail

PRACTICE IN BOILER WATER TREATMENT EMBRACES LARGE VARIETY OF METHODS EACH ADAPTED TO THE PREVAILING INDIVIDUAL CONDITIONS

CONSIDERATIONS of boiler water treatment in the 22 stations listed in this survey, since the plants considered are all new or are included only because of recent additions in motive power, would be, alone, inadequate. Many of the older stations, after experiencing difficulties of various kinds with their original treatment installations, have made important changes. Hence such experiences have been included in this analysis of development.

USE OF EVAPORATORS INCREASES

Marked increase in use of evaporators is noted in established stations although only 9 of the 22 listed in the table report evaporator installations. Five of the plants listed report treatment of water fed to evaporators but investigation of established stations indicates a much larger percentage that use this device. One operating company uses evaporators in all of its high pressure plants. A large proportion of established plants pre-treat the evaporator feed, some using zeolite softeners for this purpose.

Many plants, using evaporators, treat the entire boiler feedwater, including condensate and make up, before it enters the boilers. In this case, it is found that addition of sodium phosphate and of soda ash is necessary in order to maintain positive alkalinity. Some plants add caustic soda when the boilers are being refilled, while others make weekly tests from every boiler in order to control the sulphate-carbonate ratio and thus prevent embrittlement. One of these plants, the Toronto plant of the Pennsylvania-Ohio Power & Light Co., uses Glauber's salts to keep the ratio of sodium sulphate to sodium carbonate above 3.5 in order to prevent embrittlement. Two plants treat only the evaporator distillate in order to produce the desired alkalinity.

Treatment of make-up water to the evaporators appears to be particularly beneficial where the evaporator feed has properties producing very hard scale. In such cases the difficulties encountered due to the use of the treatment, are considered inconsequential if the process is properly supervised. This same comment applies where treatment is used to accomplish positive alkalinity.

LOWER VELOCITY REDUCES CARRY-OVER

To remedy excessive carry-over from the fourth effect of a four effect evaporator installed at the Crawford Avenue Station, a second fourth effect which operates in parallel with the original fourth effect, was installed. This reduced the velocity of the vapor leaving the two fourth effects. At first this was operated with zeolite-treated water but later was changed to use raw filtered water. Resulting scale is removed by routine cracking down which, however, does not entirely prevent the formation of hard scale on the tubes and trays so that thorough cleaning is necessary about every two months.

Results of tests on this equipment, one using zeolite treated water and the other using raw filtered water, are given in the following table:

WATER ANALYSIS — TEST NO. 14 — FOSTER WHEELER EVAPORATOR—CRAWFORD AVENUE STATION—OCTOBER 25, 1928

	P.p.m. Filtered River Water Permutit Treated	P.p.m. Distillate Final Effect
Siliceous matter, SiO_2	0.51	trace
Oxide of iron and alumina ($Fe_2O_3 + Al_2O_3$)	1.37	0.17
Sodium chloride, NaCl	40.90	1.54
Sodium sulphate, Na_2SO_4	39.85	1.54
Sodium bicarbonate, $NaHCO_3$	118.50	0.51
Calcium carbonate, $CaCO_3$*	0.34	0.34
Magnesium carbonate, $MgCO_3$**	0.34	0.17
Organic and volatile	22.60	1.37
Total solids	224.41	5.64
*Exists in the water as bicarbonate, $Ca(HCO_3)_2$	0.51	0.51
**Exists in the water as bicarbonate, $Mg(HCO_3)_2$	0.51	0.34

From this table it will be seen that considerable improvement appears in the quality of the product over that obtained from the original installation.

Only three of the plants investigated report use of no treatment system and one of these filters its makeup. Most of the stations use combination treatment systems following the general trend that has been effective for a few years. In connection with this, it will be noted that the variety of treatments used is considerable, emphasizing the need for special consideration of each individual case, so strongly advocated in these columns for the past two years. Of all the divisions of steam power plant operation, the boiler water treatment division is the one that can least afford to be designed by cook-book methods.

ZEOLITE TREATMENT SERVES EVAPORATORS

Zeolite methods, although not widely specified for the new stations listed, are being used in many established plants in combination with other treatment systems and in some cases this method is used to treat the water served to evaporators. In one plant which employs a unit system of evaporators, a zeolite softener is used ahead of only one of the four units. Another company which operates, mostly, relatively small sized low-pressure generating stations, uses zeolite softeners in all of them. One plant that, in the past, had used zeolite softeners on the evaporator feed has discontinued this practice and now feeds raw water to the evaporators.

Some difficulties have been experienced with mud deposits on the tanks and zeolite, which is not removed by back washing, where this process is used. One plant has difficulty through the formation of channels in the zeolite and if water velocities are increased in order to agitate the zeolite, the mud is carried over.

Natural brines, such as seawater and flow from salt wells, are now successfully employed for regeneration

FEEDWATER TREATMENT & HEATING

	NAME OF STATION	TREATMENT: SOURCE OF MAKE UP	SYSTEM	IS WATER TO EVAP TREATED?	BLOWDOWN: PERIODS	BLOWDOWN: TOTAL FEED	BLOWDOWN: INTERM OR CONTIN	LIMIT OF CONCEN. GRAINS PER GALLON	HEATING: SOURCE	HEATING: TYPE HEATER	FINAL F.W. TEMP °F	STAGE WATER HEATING TEMPERATURE: EJECTOR IN	EJECTOR OUT	OIL COOLER IN	OIL COOLER OUT	GEN. AIR COOL. IN	GEN. AIR COOL. OUT	DEAER. HTR. IN	DEAER. HTR. OUT	EVAP. IN	EVAP. OUT	ECON. IN	ECON. OUT	EXTRACTION HTRS. NO. 1 IN	NO. 1 OUT	NO. 2 IN	NO. 2 OUT	NO. 3 IN	NO. 3 OUT	NO. 4 IN	NO. 4 OUT	NO. 5 IN	NO. 5 OUT
CENTRAL STATIONS	DEEPWATER	WELLS	EVAPORATORS	NO	24 HR. EST	1.5 EST.	INT.	30	EXTRACTION	CLOSED	430	78	81	—	—	—	—	150	210	—	—	430	STM 458	81	150	210	267	267	341	341	434	—	—
	HOLLAND	RIVER	SEDIMTATION, ZEOLITE EVAPORATION	YES ZEOLIT	CONTIN.	—	—	—	"	"	433	—	—	—	—	—	—	206	272	172.8	206	431	522	82.8	172	172.8	206	206	272	272	330	330.6	433
	STATION A	CITY	HOT LIME & SODA EVAPORATOR	YES	—	0.7	INT.	—	"	CLOSED & DEAERAT'R	436	86	89	—	—	—	—	182	239	—	—	436	546	360	436	276	360	239	276	89	182	—	—
	HELL GATE 29 & 30	"	TRI SODIUM PHOSPH.	NO	THIS WILL BE DETERMINED AFTER BOILER IS INSTALLED				EXT. & EXH. FROM PUMP & FROM FAN	CLOSED	350	AFTER COOL'R 77	78.5	—	—	—	—	SALT WATER		—	—	—	—	78.5	192	192	210	210 ②	270 ②	—	—	—	—
	EAST RIVER ADDITION	"	" "	"	—	—	—	—	EXT. HTRS. 3 & 4 EXH. AUX. IN #2	"	360	92	93	—	—	—	"		"	—	—	—	—	93	153	153	210	210	280	280	360	—	—
	STATE LINE	LAKE	EVAPORATOR	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	CAHOKIA	RIVER	LIME IRON SULPHATE BARIUM HYDRATE	YES	30 DAYS	0.02	INT.	3.0 CHLORIN	EXT. HSE. TURB. EXHAUST	CLOSED & DEAER.	310	—	89	108	111	89	108	173	213	—	—	—	—	123 ①	173	—	—	213	310	—	—	—	—
	DELRAY #3	"	EVAPORATOR	NO	—	—	INT.	—	EXTRACTION	CLOSED	340	—	—	68	75	68	80	—	—	50	223	320	370	75	140.8	142.4	212.3	212.3	276.1	276.1	349.7		
	OHIO RIVER	CITY	"	—	—	—	—	—	"	"	200	—	—	—	—	—	—	—	—	—	—	220	327	79	167	167	220	—	—	—	—	—	—
	GORGAS #2	RIVER	"	NO	AS REQ'D.	—	INT.	NOT KNOWN	"	"	392	101	101.5	— NOT IN FEED W. CYCLE —				75	210	210	280	NONE		101.5	169	170.5	235	278	318	318	388	—	—
	RIVERBEND	"	"	NO	—	—	INT	—	"	"	349	99	101.4	—	—	③	—	198.5	250.3	210	289	"		288	349	250.3	288	181.4	198.3	181.4	181	NONE	
	ENGLISH ADD	CITY	SODIUM PHOSPHATE	—	8 HR.	VARIES	INT.	—	DEAERATING	DEAERAT'R	214	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	FREMONT	WELLS	NONE	—	8 HR.	0.8	INT.	100	EXT. & EXH. AUX.	"	250	89	160	125	100	88	85	200	210	NONE		200	250	—	—	—	—	—	—	—	—	—	—
INDUSTRIAL STATIONS	WAUKEGAN N.S.C. & C.C.C.	LAKE	HOT LIME & SODA	—	8 HR.	—	CON.	250	EXTRACTION	OPEN	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	ST PAULS SCHOOL	RIVER	SODA ASH	—	—	—	—	—	TURB. EXT.	CLOSED	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	VISCOSE MEAD VILLE	WELLS	ZEOLITE & ALUM	YES	8 HR.	—	—	5	EXTRACTION	OPEN	220	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
	NEW HAVEN P. & BD. CO.	CITY	COMPOUND	NO	4 HR.	—	INT	120	TURBINE EXH.	OPEN DEAE	225	—	—	—	—	—	—	—	—	—	—	NONE		—	—	—	—	—	—	—	—	—	—	—
	HARRIMAN	RIVER	NONE	NO	—	4	CON.	400	BACK PRESS	OPEN	220	—	—	—	—	—	—	—	—	—	—	NONE		—	—	—	—	—	—	—	—	—	—
	CROCKER BURBANK	RIVER & CITY	TRI SODIUM PHOSPH.	—	8 HR	—	—	—	EXHAUST	OPEN DEAR	215	—	—	—	—	—	—	—	—	—	—	NONE		—	—	—	—	—	—	—	—	—	—	—
	AMERICAN BEMBERG	RIVER	NO TREATMENT FILTERED	—	④	—	—	④	"	OPEN	212	—	—	—	—	—	—	—	—	—	—	NONE		—	—	—	—	—	—	—	—	—	—	—
	MIAMI COPPER CO	WELL & MINE	LIME SODA SODIUM ALUMINATE EVAPORATOR	YES	IRREG.	VAR.	INT.	50	EXTRACTION EXHAUST	CLOSED DEAER.	295 TO 310	92 TO 107	100 TO 112	—	—	85 TO 100	92 TO 108	140	212 TO 225	—	—	—	—	100 TO 112	140 TO 150	212 TO 225	295 TO 305	—	—	—	—	—	—	—	—
	AMERICAN GLANZSTOFF	RIVER	FILTER LIME — SODA	NO	8 HR.	0.8	INT.	75	EXTRACTION	DEAERAT.	210	—	—	—	—	—	—	80	210	—	—	—	—	—	—	—	—	—	—	—	—	—	—

① CONDENSAT MIXED WITH THAT OF ANOTHER TURBINE AT THIS POINT.

② HEATER RECEIVING EXHAUST FROM FAN TURBINES

③ NOT IN CONDENSATE SYSTEM. EVAP. FEEDWATER HEATER IN 60°, OUT 210°

④ DEPENDS ON MAXIMUM ALLOWABLE ALKALINITY OF 20 GR. PER GAL.

in zeolite softeners. Two plants of 34,700 and 52,000 lb. per hr. capacity respectively are successfully using seawater and one 173,000-lb. per hr. plant is using natural brine from wells. This practice offers a considerable saving to central stations that are located near sources of natural brine supply as, by this means, cost of chemicals is entirely eliminated from the operating cost.

Chemical Treatment Widely Used

Chemical treatment in various forms is widely used especially where the boiler feed contains only a small amount of scale-forming matter so that comparatively small amount of treatment is necessary. One plant using chemical treatment reports considerable deposits in the superheater and on turbine blading but no difficulty is experienced in removing this deposit by washing. Another plant reports difficulty on account of the carry-over of treatment chemicals. This was overcome by the installation of steam purifiers in the boiler drums to remove the impurities in the steam and by employing continuous blowdown.

Corrosion of non-ferrous metals in bleeder heaters and evaporator condensers has been encountered and overcome in the heaters by additional deaeration of the water and venting of equipment. Correction of corrosion in evaporator condensers has been made by the installation of an open heater on the evaporator feed in order to reduce the amount of gases that would otherwise be discharged to the evaporator condenser.

Trouble with corrosion was experienced at the Beacon Street Heating Plant of the Detroit Edison Co., was attributed to the low pH value of the water occasioned by the presence of a considerable amount of $NaHCO_3$ and some CO_2 and oxygen.

Corrosion Avoided by Different Expedient

This corrosion trouble has been successfully overcome by different expedients applied to different parts of the system. In the cold water tanks and pipes, protective coatings of several kinds were tried with apparent success, although they have not been applied long enough to make a permanent decision. Cement lined pipe and pipe coated internally with bitumastic paint is being tried. Cadmium plating is being tried on the trays of the feedwater heaters and gives promise of success. Corrosion in the hot boiler feed lines and in the boilers has been apparently eliminated by the simple expedient of recirculating sufficient blowoff water, which is highly caustic, back into the water space of the heater. By this means all free CO_2 in the initial water is converted into sodium carbonate and the sodium bicarbonate, also, is converted into sodium carbonate, thus making the water non-corrosive. Protective coatings are applied also to the drums. This experience emphasizes the fact that with water containing considerable sodium bicarbonate and free CO_2, corrosion is likely to occur even though the oxygen content is exceedingly low.

In a recent report of the Chemists' Subcommittee of the Prime Movers' Committee of the N.E.L.A., however, emphasis was placed on the necessity of freeing boiler feedwater of all oxygen and on the advisability of making oxygen determinations at the first indication of corrosion. The Winkler Iodimetric method, which is described, is recommended for all boiler feedwater supplies except raw water, for which, if appreciable amounts of organic matter, iron salts or nitrates are present in appreciable amounts, the Rideal-Stewart method is recommended.

Pressure Rise Accelerates Embrittlement

Tendency toward embrittlement of boiler drums is much more marked as the operating pressure and temperature of water are raised. Accelerated embrittlement laboratory tests have shown that for standardized conditions flange steel has cracked in 720 hr. for 100-lb. steam pressure, in 30 hr. for 500-lb. press. and in 10 hr. for 1000-lb. press. This greater tendency toward embrittlement incidental to higher operating pressures has introduced a problem in many stations which, with relatively good water conditions and lower operating pressures, would otherwise have never needed consideration as an important operating problem.

Two solutions of this problem are recommended: First, the use of effective inhibitors. Maintaining a proper ratio of sulphates to carbonates by the injection of sulphuric acid into the feedwater can be accomplished but it may increase the amount of sulphates to such an extent as to make the solution undesirable. It has been found that relatively small amounts of phosphate will serve effectively to inhibit embrittlement.

The second solution for embrittlement troubles recommended, is the use of forged or hammer-welded boiler drums instead of riveted drums. In general, the practice has been to use forged drums for operating pressures in excess of 700 lb.

At the Columbia Station of the Union Gas & Electric Co., the ratio of sodium sulphate to sodium carbonate recommended to prevent embrittlement is maintained by treating the river water with lime and soda ash and using ferrous sulphate as a coagulant. Later, disodium phosphate was added continuously to the condenser hot wells in sufficient quantity to maintain a phosphate concentration of 50 p.p.m. in the boiler water. The boiler blowdown was also so regulated that the total solids in the boiler water did not exceed 1000 p.p.m. This phosphate treatment was found successfully to eliminate scale formation in boilers operating at 15 k. B.t.u. per sq. ft. per hr. average rating. Embrittlement was also found to be inhibited.

Employment of Deaerating Heaters Increases

Increased use of deaerating heaters is indicated by the fact that eight stations, of those surveyed, reported such use. Of the plants investigated, most of them report use of intermittent blowdown; only two report use of the continuous system. In one continuous blowdown system, to which is added an acid feed, part of the alkaline boiler blowoff water is continually added to the acid-treated water after aeration.

Reduction of required makeup water has reached that stage which makes it possible for the average plant to maintain this necessary quantity to within 1 per cent of the total and this quantity may be easily evaporated with inappreciable loss due to the degrading of heat. For boiler plants requiring a high percentage of makeup, equipment is now available which makes it possible to maintain conditions of operation and a degree of reliability and availability of boiler units closely approximating that for boilers operating on distilled water.

TURBINES, CONDENSERS and AUXILIARIES

Higher Prime Mover Efficiency Predicted

INCREASE IN SIZE, IN STEAM PRESSURE AND VARIED ARRANGEMENT ARE FEATURES. BY E. E. GILBERT*

INITIAL PROGRESS made during the past year in steam turbine-generator construction has been greater than in any previous year and the total sales have also been greater. The total capacity of machines put in operation and the maximum capacity of individual units such as the 208,000-kw. triple compound machine supplied the State Line Generating Co., the 165,000-kw. triple compound machine supplied for the Philo Station of the Ohio Power Co., and the 160,000-kw. tandem compound machine supplied the New York Edison Co. for its East River Station, all represent material advances in steam turbine development.

Generators for the 208,000-kw. State Line unit and the generators supplied the Super Power Co., Powerton, Ill., are worthy of special attention, as they are wound for 22,000 v., which is a definite advance in generator design and construction. The 160,000-kw. machine in the East River Station of the New York Edison Co. is equipped with a double winding which is another definite step in the design and construction of large generators for the distribution of power. The turbine of this unit is placed over the largest capacity single condenser ever built. The generator stator of this machine owing to its enormous weight was built at East River Station. The body portion alone weighs 228,000 lb. and involved the largest single forging ever turned out by the steel mills. A billet weighing some 465,000 lb. was used.

Now under construction is a 110,000-kw. unit of the vertical compound type designed for 1200 lb. steam pressure for the Ford Motor Co., a development which will, undoubtedly, have an important bearing on power station development for the future.

Outstanding among developments during the year has been the successful manufacture and increasing use of 1200 lb. steam pressure. Turbines for a pressure of 1200 lb. totaling 512,000 kw., are installed or under construction. No unusual difficulties which could be attributed to high pressure were experienced with the turbines in service; in fact, the units are started, stopped and otherwise handled with the same ease as are large turbines operating at lower pressures.

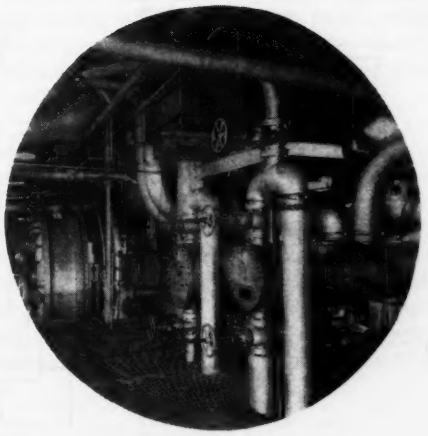
Such achievements as successfully building units of exceptionally large capacity for high steam pressure, high voltage or other unusual and important characteristics are made possible as a result of the research work that has been carried on for many years and is being carried on even more intensively at the present time.

It seems proper also to call attention to the steamship California, the first large passenger vessel in the world to adopt electric drive which was put in service during 1927. A sister ship, the Virginia was put in service in 1928 and a third ship, the Pennsylvania has also been put in service and has just made her maiden trip. Other steamship companies, such as the Ward, Grace and Dollar Lines, have placed orders for turbine electric drive equipment to be installed on similar ships.

As to the future, it would seem that so far as turbine-generator equipment for power service is concerned, the outlook is more promising than it has been at any time in the past because of the fact that many important advances in the art are now under consideration which will result in higher efficiencies and greater reliability in service.

*Sales Manager, Turbine Dept., General Electric Co.

Steam Temperatures of 1000 deg. F. now Seem Practical



10,000 Kw., 1000 Deg. F. Turbine, Four All 1200 Lb. Stations, Combination Industrial and Central Station Plants, and High Pressure Industrial Evaporators Are Developments Which May Change Established Heat Balance Layouts

PROBABLY the most important development of the year from the standpoint of increased economy of the steam cycle, is the high temperature installation at Delray No. 3. A separately fired superheater designed to give a steam temperature of 1000 deg. F. at 400 lb. pressure has been in operation for some time and a 10,000-kw. turbine has been ordered.

Announced as an experimental installation, it never-

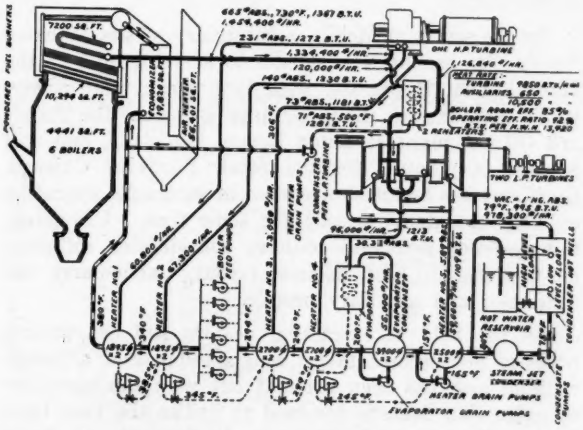


FIG. 1. AT 150,000 KW., THE STATE LINE TURBINE AND AUXILIARY HEAT RATE IS 10,500 B.T.U. PER KW-HR.

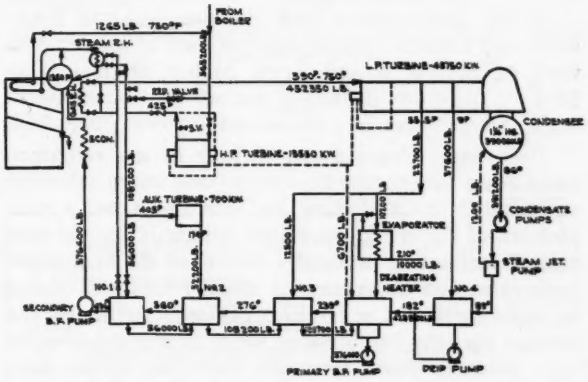


FIG. 3. HEAT BALANCE DIAGRAM OF STATION A AT THE MAXIMUM LOAD OF 63,000 KW.

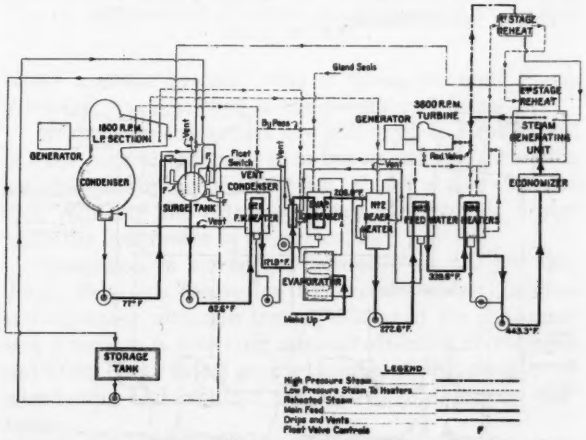


FIG. 2. HOLLAND USES A COMBINATION OF GAS AND STEAM REHEATERS

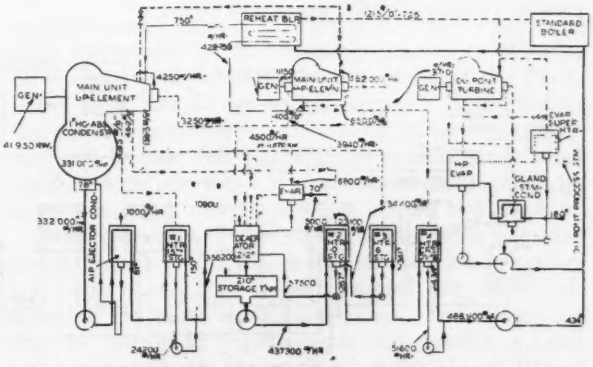


FIG. 4. DEEPWATER STATION HEAT BALANCE AT A LOAD OF 53,100 KW. THE TURBINE ROOM HEAT RATE AT THIS LOAD IS 9450 B.T.U. PER KW-HR.

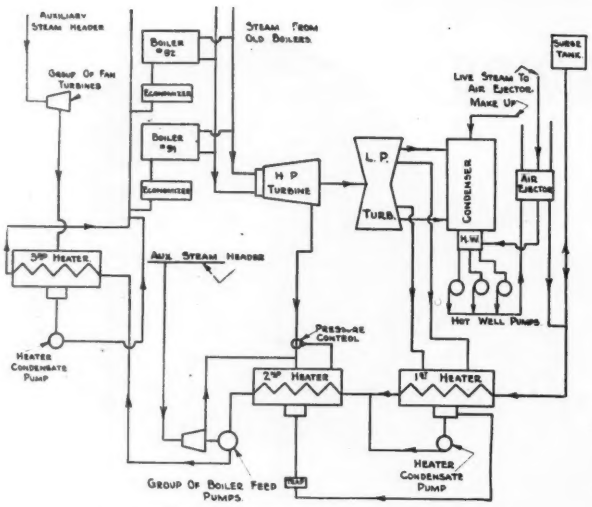


FIG. 5. - HELL GATE STATION FLOW DIAGRAM

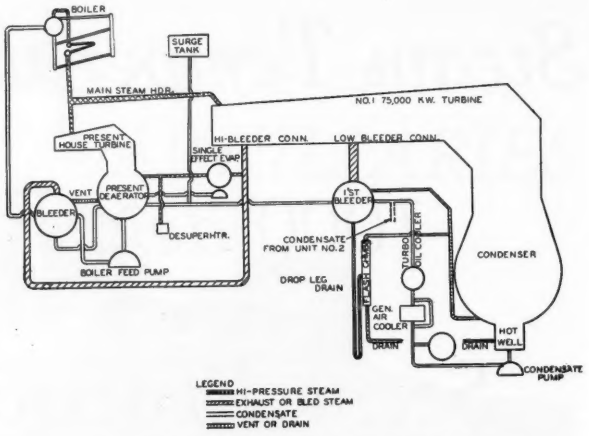


FIG. 7. FLOW DIAGRAM OF THE NEW NO. 1, 75,000-KW. UNIT AT CAHOKIA. EXTRACTED STEAM FROM THIS UNIT HEATS THE CONDENSATE FROM THE OLDER NO. 2 UNIT

theless may be regarded as no more, if as much, of an experiment as 1200 lb. pressure at Edgar a few years ago. The well known conservative policy of the Detroit Edison Co., the intensive study they have made of the European high temperature field, the consistent way in which they have avoided high pressures and the size of the unit selected lends support to the feeling that although it is an experimental installation it is made with little anticipation of failure.

In the high-pressure field, the completion of Deepwater and Holland stations and the start of construction work on Station A and South Amboy Stations takes 1200 lb. pressure definitely out of the experimental stage and stabilizes its position in the power plant field.

Deepwater reheats steam entirely by gas reheaters, while State Line, a 665-lb. station, uses steam reheaters exclusively. Both Holland and Station A use a combination of steam and gas reheat primarily for the purpose of facilitating automatic control of the final steam temperature on reheating. A steam reheater is placed in series with the convection gas reheater in such a manner that the low pressure steam is first reheated by high pressure steam from the boiler drum and then passed through the convection heater. The relative proportion of the reheating performed by the steam section decreases with higher boiler ratings because of the increased temperature of the gases of combustion and the greater velocity of both steam and gases.

Another development, which although not entirely new, has never been fully developed before, is the full coöperation between central stations and large industrial companies. Deepwater is selling high pressure steam to the Dupont Co., the agreement being such that the Dupont Co. takes the entire electrical output and all the exhaust steam from one high back pressure unit in the station.

In the south, at Mobile, a subsidiary of the Alabama Power Co. has built a station to serve a mill of the International Paper Co. with both steam and power, while another such plant is under way near the Standard Oil Co. plant at Baton Rouge, Louisiana, and still another is planned for the Stock Yards of Chicago. Rochester has had such a system in successful operation on a more extensive scale for some time. Ultimately this practice is bound to have considerable influence on the station heat balance layout, particularly the condenser and auxiliary practice.

In the field of extraction heaters and evaporators practice has become fairly well standardized although nothing new has been brought out with the exception of extraction heaters designed to utilize the heat head of steam extracted in the superheated region. Practically all stations now extract considerable steam in this field in contrast to the rather recent feeling that this was not advisable.

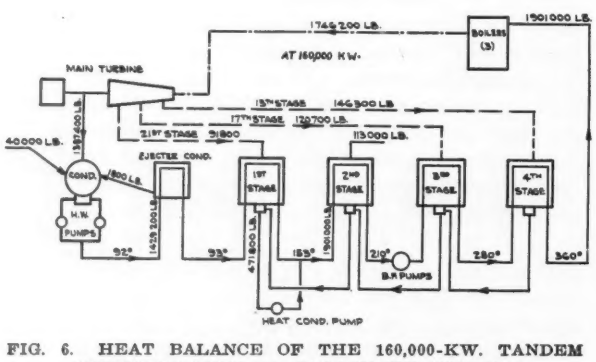


FIG. 6. HEAT BALANCE OF THE 160,000-KW. TANDEM COMPOUND UNIT AT EAST RIVER STATION

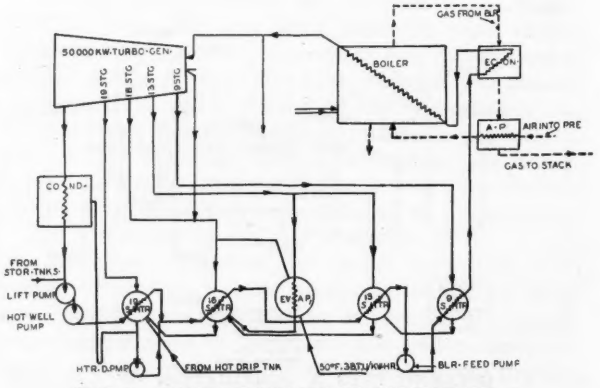


FIG. 8. FLOW DIAGRAM AT DELRAY NO. 3

In general, the number of extraction heaters are gradually increasing. Four stages are now common while five stages are used at State Line. Comparatively low-pressure extracted steam is now almost always used for evaporators and this combined with the low percentage of makeup required in the modern station has placed the single effect evaporator in practically universal use both in the central station and industrial field.

Two interesting installations of high-pressure evaporators have been made in industrial plants for supplying considerable quantities of process steam. Both plants are using 400 lb. pressure boilers and supplying 150 lb. process steam, the high-pressure installation being virtually a closed system. One of these, the Gulf States Steel Co., was described in the December 1 issue.

Evaporator condensers are still used to some extent but the general tendency is to use one of the extraction heaters, usually around 210 deg. F. for evaporator service, reducing the extracted steam flow to this heater while the evaporator is in service.

Deaeration is considered necessary in all new stations. Separate deaerating heaters are widely used as at Deepwater, although the popularity of the condenser as a deaerator is receiving unusual attention, State Line and Ohio River being good examples of the practice of introducing makeup into the hotwell of the main condenser.

This arrangement not only eliminates the complication of the open heater but makes the introduction of a surge tank immediately following the hotwell pump simple. The use of the surge tank at this point, before the condensate is heated, allows the storage of condensate at hotwell temperature, reducing radiation losses and insulation costs.

Industrial plants have been going to higher and higher pressures in order to get the proper balance of steam and electric loads. Accumulators are being used to an increasing extent for industries having irregular steam loads and the extraction mixed pressure turbine, as used at the American Bemberg plant is being used to a certain extent. The application of these turbines depends either upon the use of noncondensing prime movers or auxiliaries or upon the return of condensate from the process work. The latter is not often practical while the possibilities of the former scheme are becoming more limited due to the increasing popularity of motor drive. The 1840-lb. industrial installation of the Philip Carey Mfg. Co. is not yet in service. Reciprocating engines of small capacity exhausting at high back pressure will be used and although the experiment is being watched with interest, it is not likely to have undue influence on either the industrial or central station plant.

Heat economies of new stations have so far exceeded the performance of old ones during the past few years that new plants were often designed for base load, throwing the peaks on the older ones. Indications are that the amount of improvements still possible is small and many engineers are questioning the advisability of adding new base load stations to present systems. In fact, the design of peak load stations with large units

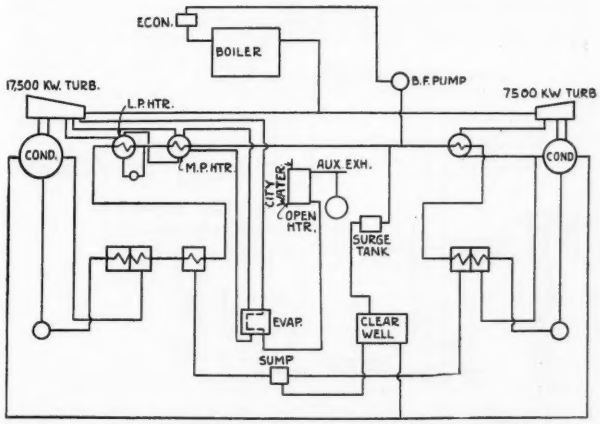


FIG. 9. OHIO RIVER STATION FLOW DIAGRAM, USING TWO UNITS OF DIFFERENT SIZE

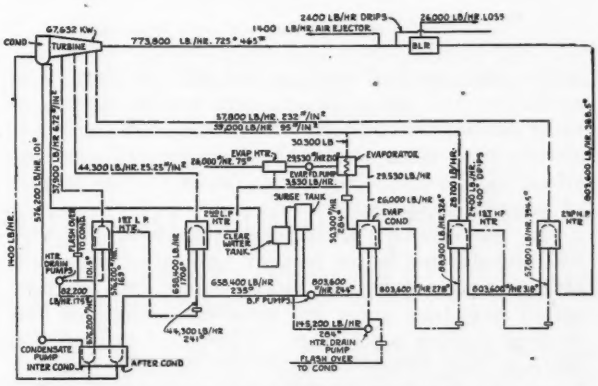


FIG. 10. GORGAS UNIT NO. 4 HEAT BALANCE AT A LOAD OF 67,632 KW.

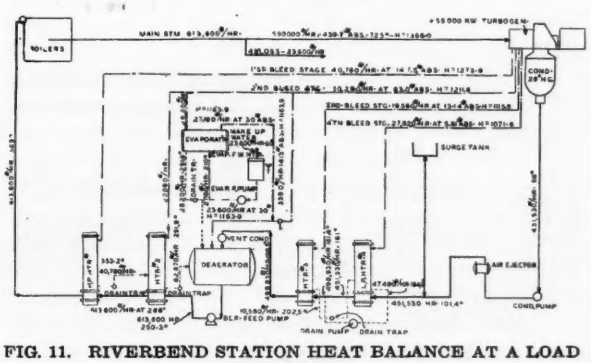


FIG. 11. RIVERBEND STATION HEAT BALANCE AT A LOAD OF 55,000 KW.

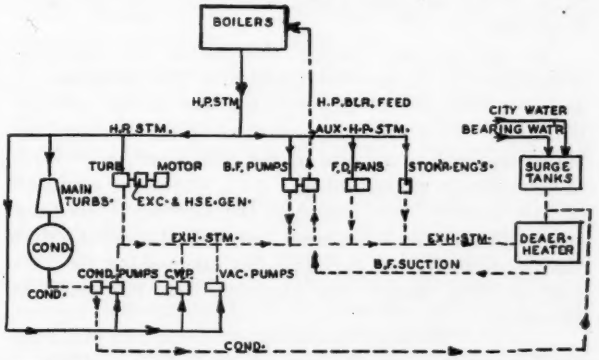


FIG. 12. FLOW DIAGRAM ENGLISH STATION WHERE FEEDWATER IS HEATED BY AUXILIARY EXHAUST

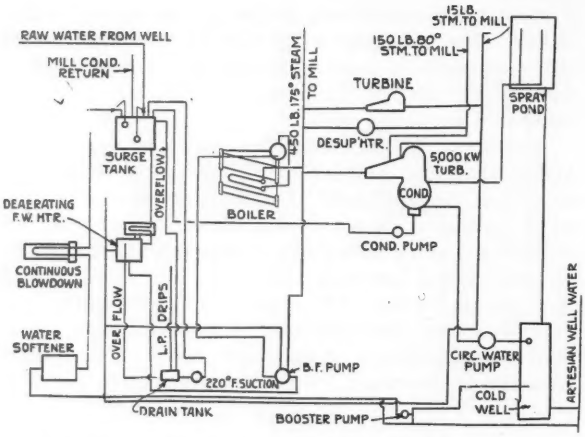


FIG. 13. MEADVILLE PLANT OF THE VISCOSE CO.

with a wide range of capacity and with the simplest of auxiliaries and the minimum heat savings devices, is being seriously considered. In Europe, such steps have already been taken, stations in Germany utilizing both Diesel engines and steam accumulators for the purpose of carrying peak loads.

In this country, actual developments of this type will probably not be put in form until after the results of high temperature and binary vapor tests are completed or at least under way a sufficient length of time to draw definite conclusions. When it is realized that the heat drop through a single 400 lb., 1000 deg. turbine without reheat is about the same as the reheat installation at Philo the advantage of high temperatures, even if separately fired superheaters are necessary, is evident.

In the mercury vapor installation at Hartford, promising results were obtained and heat economies in the neighborhood of 10,000 B.t.u. per kw-hr. actually obtained. With increased pressures of the mercury and steam and minor changes in the equipment, 8500 B.t.u. is not entirely unthought of. As a whole, the engineers of this country have looked at the mercury cycle progress with a passive interest, not only unconvinced of the practicability of the cycle but questioning its justification even though the expected heat economies be obtained.

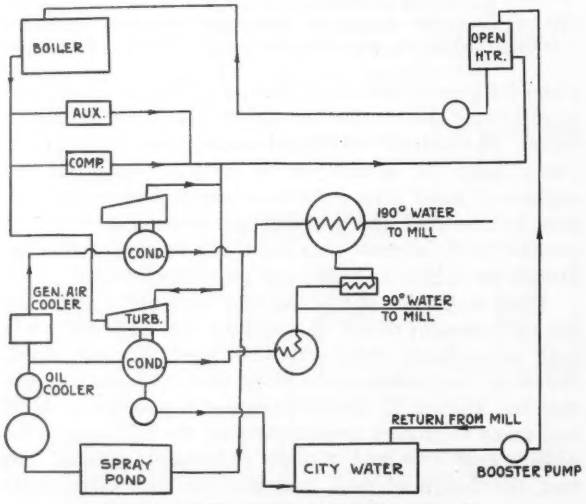


FIG. 14. THE AMERICAN BEMBERG CO.

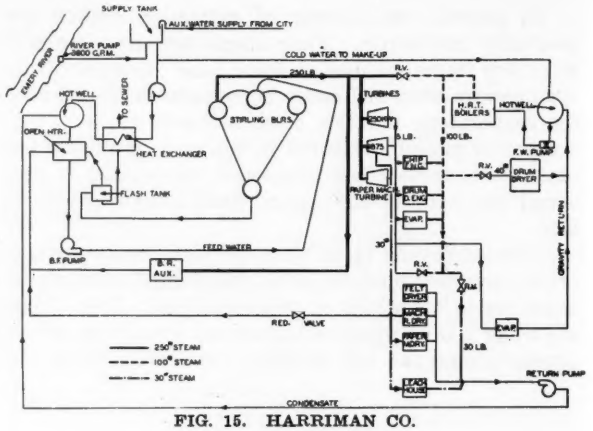


FIG. 15. HARRIMAN CO.

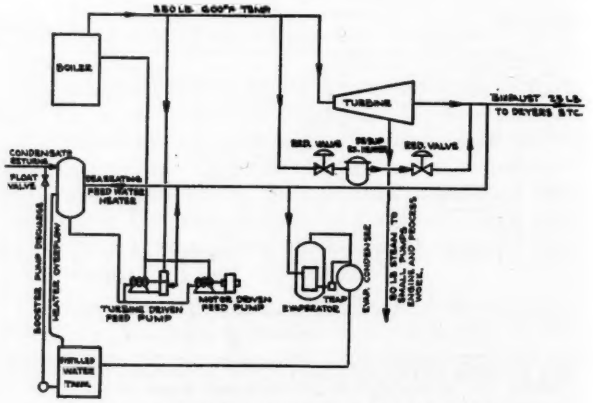


FIG. 16. NEW HAVEN PULP & BOARD CO.

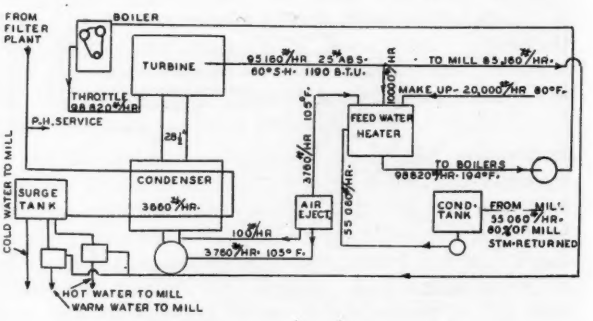


FIG. 17. AMERICAN GLANZDORF CO.

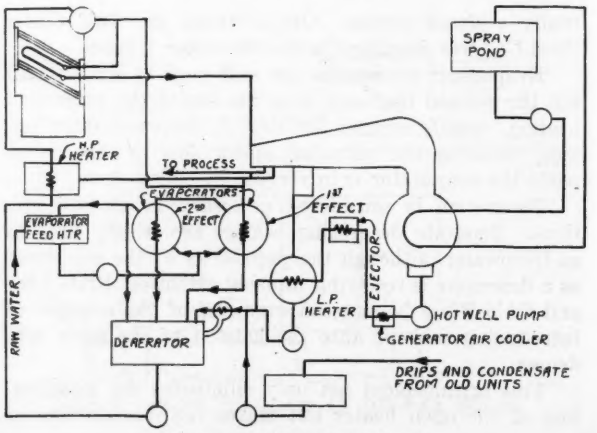


FIG. 18. MIAMI COPPER CO.

One avenue of approach to better overall system economies and one which is bound to receive increased attention as time goes on is the rehabilitation of comparatively recent existing power plants that have been left behind by progress during the past few years. Superimposing 1200 lb. on a 300 or 400-lb. station has been successfully accomplished. Change of existing turbines so as to make cross compound units out of them has also been tried although probably the arrangement which will be of most service to the average station of this type is the addition of new units designed for increased bleeding so as to take care of the high temperature feedwater heating of the older non-extraction units. This was successfully accomplished at Cahokia where a new turbine bleed at two points heats the condensate from the old No. 2 unit, using approximately double the quantity of extracted steam that would otherwise have been the case.

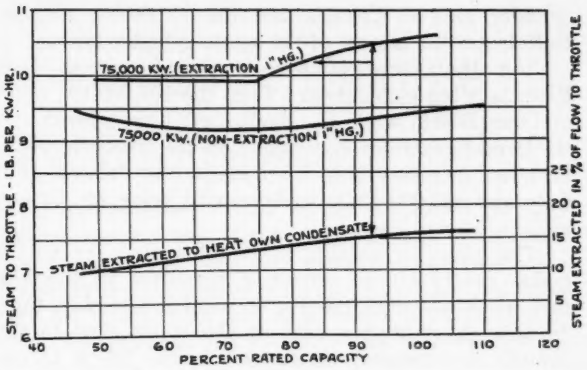


FIG. 19. CURVES SHOWING THE AMOUNT OF STEAM EXTRACTED AT VARIOUS LOADS. THIS IS FOR THE 75,000-KW. CAHOKIA TURBINE

In spite of the changes and refinements, that have taken place during the past few years, it is interesting to note that Columbia, a comparatively old station, and one of the first of reheat design to be installed, still holds the record for thermal economy with something better than 12,500 B.t.u. per kw-hr. sendout.

Turbine Sizes and Temperatures Increase

208,000-Kw. Cross Compound, 160,000-Kw. Tandem Compound and 75,000-Kw. Single Cylinder and Cross Compound Industrial Turbines in Operation

ONE OF THE INTERESTING turbine developments of the past year has been the popularly termed steeple compound turbine designed primarily for 1200 lb. pressure. These turbines are built with the 1200-lb. element on top of the low pressure element as shown in both Fig. 1 and Fig. 2. The first is the type installed in Station A, 55,000-kw. cross compound machines. Although rated at 50,000 kw. they are capable of a maximum output of 62,000 kw. Provision is made for operating the low pressure elements direct from the boiler with the high pressure turbine shut down.

A somewhat similar unit will be installed in the River Rouge plant at Detroit. This is shown in Fig. 2. Each element will have a capacity of 55,000 kw., making this both the highest pressure and largest industrial turbine in the world. The 1840-lb. industrial plant in Ohio will use reciprocating engines in small sizes.

Use of vertically compounded turbines is instrumental in reducing the turbine room volume, the 110,000-kw. unit above occupying less than 0.25 cu. ft. per kw. of capacity. In fact, reduction of building volume from 25 to 50 per cent is one of the big advantages of high-pressure, high capacity machines. For instance, Deepwater Station shows a reduction from 0.63 to 0.40 cu. ft. per kw. over Toronto Station. These latter figures include the volume above the basement floor and not the turbine alone.

Another development destined to be of importance in the future is the 10,000-kw. turbine being built in England for Delray No. 3. If successful, as no doubt it will be, the influence it will exert on station design is evident.

At State Line Station, the 208,000-kw. cross compound, three-element machine that created so much interest 2 yr. ago is in service but because of the increased development of other type turbines and increased interest in 1200 lb. pressure, interest in this type size and pressure turbine seems to have waned.

Although the high pressure element at State Line is the largest single cylinder turbine yet built, 76,000 kw., it is not generally considered as such because expansion of the steam is only partially. The 75,000-kw. single

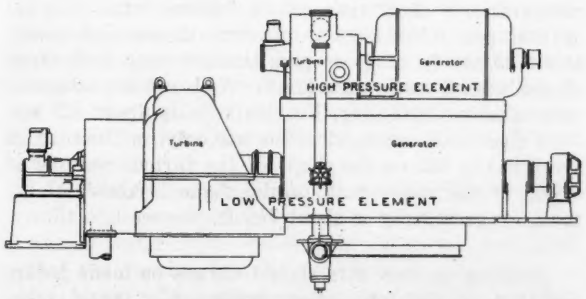


FIG. 1. GENERAL ARRANGEMENT OF THE 1200-LB. CROSS COMPOUND TURBINES AT STATION A

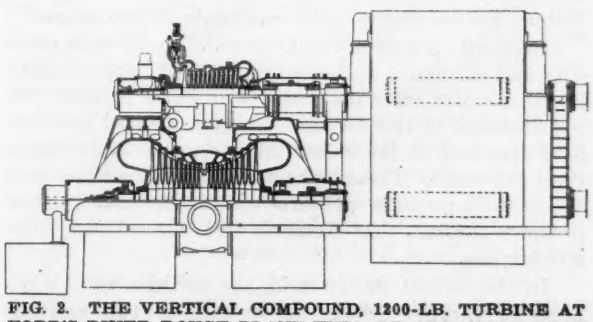


FIG. 2. THE VERTICAL COMPOUND, 1200-LB. TURBINE AT FORD'S RIVER ROUGE PLANT WILL BE ARRANGED LIKE THIS

cylinder unit at Cahokia and the 75,000-kw. unit at Buffalo are the largest of the single cylinder type.

The 160,000-kw. tandem compound unit at East River is a big step forward from the 104,000-kw. units at Long Beach, while the double winding generator is the largest generator ever built. In the cross compound field, no increases have been made, the 165,000 Hell Gate and 165,000 Philo turbines still being the largest built.

The Cahokia installation is interesting in that it makes use of higher extraction pressures on the new turbine to heat condensate from another and older unit. In this about 23 per cent of the steam flow to the throttle is extracted, in contrast to the 10 or 11 per cent which would be utilized to heat its own condensate.

practical method of rehabilitating comparatively new but not modern plants. This was successfully accomplished at Columbia where the tandem compounds were changed to cross compounds with a material increase in capacity.

Initial 1200-lb. units installed at Edgar and Lakeside stations were for the purpose of superimposing the 1200-lb. cycle on an existing 350-lb. station. These were single valve machines operating on base load and exhausting at constant pressure.

In the later plants, multivalve turbines are used as they will be called upon to carry varying loads and a uniform turbine economy is desirable over as wide a range as practical. Both reaction and impulse types are used for 1200 lb. pressure although the former are

STEAM TURBINES

	NAME OF STATION	NO. & RATED CAP. OF MAIN TURBINES (INC. EXCITERS & SHAFT GEN.)	TYPE	SPEED R.P.M.	NO. OF STAGES OR ROWS OF BLADES	STEAM CONDITIONS: THROTTLE LB. ABS.	THROTTLE DEG. FAHR.	REHEAT LB. ABS.	REHEAT DEG. FAHR.	EXHAUST PRESSURE ABS.	MAXIMUM TOTAL STEAM FLOW TO THROTTLE LB./HR.	EXTRACTION: TOTAL LB./HR.	PER CENT TOTAL TO THROT.	FIRST LB. ABS.	FIRST DEG. F.	SECOND LB. ABS.	SECOND DEG. F.	THIRD LB. ABS.	THIRD DEG. F.	FOURTH LB. ABS.	FOURTH DEG. F.	FIFTH LB. ABS.	FIFTH DEG. F.	PURPOSE
CENTRAL STATIONS	DEEPWATER	2-53,000 1-12,500	COMP. IMP. CYL.-IMP.	H.P. 3600 L.P. 1800 3600	14 17 14	1215 1215	725 725	403 —	750 —	1" 400 LB	482,000	150,000	31·1	400	484	38·5	548	46.2	350	44.5	157	—	—	F.W. & EVAP.
	HOLLAND	1-55,750	COMP IMP.	H.P. 3600 L.P. 1800	14 17	1250	750	415	750	1"	495,000	155,100	31·4	416	517	144.8	538	48.8	340	15·3	217	8.32	183	F.W.- EVAP. & DEAER.
	STATION A	2-50,000	VERTICAL COMP. IMP.	HP 3600 LP 1800	14 17	1265	750	390	750	1 1/4"	385,000	175,000	31	420	520	55	357	9	188	—	—	—	—	F.W.-EVAP. & DEAER.
	HELL GATE	1-165,000	IMP. REAC. X COMP.	1800	22	280	700	—	—	1"	1,648,575	178,970	10·85	37.5	319	12·0	202	—	—	—	—	—	—	F.W. HEAT.
	EAST RIVER	1-160,000	T. COMP. IMP.	1500	24	375	700	—	—	1"	1,746,000	358,800	20·5	173	370	57.5	290	1·8	122	—	—	—	—	F.W. HEAT
	STATE LINE	1-208,000	3 ELEMENT X COMP. IMP.	1800	H.P. 16 L.P. 16	665	750	72	500	1"	1,981,000 [A]	455,000 [B]	23.2	231	517	140	1230 418	73	1151 305	30.3	348	5.89	189	F.W. & EVAP.
	CAHOKIA	1-75,000	CYL.-IMP.	1800	17	315	725	—	—	1"	825,000	191,900	23.3	100	328	8.3	184	—	—	—	—	—	—	F.W. & EVAP.
	DELRAY	2-50,000	IMPULSE 1 CYL.	1200	21	390	255	—	—	1"	605,000	134,212	25.5	137.5	520	47.7	277	16.31	215	33.6	14	—	—	F.W. HEAT. & EVAP.
	OHIO RIVER	1-7500 1-12,500	1 CYL.-REAC. 1 " "	1800 "	49 —	390	690	—	—	1"	— 129,370	— 17,500	— 13·5	21.0 190		6.7 81	—	31	—	7.27	—	—	—	—	F.W. & EVAP.
	GORGAS	1-60,000	1 CYLINDER IMPULSE	1800	17	400	727	—	—	2"	666,000	187,200	23·2	238	392	106	329	30	245	9	184	—	—	F.W., EVAP. & DEAER.
	RIVERBEND	2-55,000	1 CYLINDER IMP.-REAC.	1800		440	725	—	—	2"	590,000	138,470	23·5	142.5	507	63	358	13.14	204	55.81	1.67	—	—	F.W., EVAP. & DEAER.
	ENGLISH ADD.	2-12,500	1 CYL.-IMP.	1800	9	365	561	—	—	2"	145,000	—	—	—	—	—	—	NO EXTRACTION	—	—	—	—	—	—
	FREMONT	2,500	1 CYL.-IMP.	3600	13	300	558	—	—	1"	30,000	—	—	—	—	—	—	—	—	—	—	—	—	F.-W.
INDUSTRIAL PLANTS	WAUKEGAN N.S.C. & C. CO.	2-750	1 CYL. REACTION	3600	—	225	530	—	—	1"	25,600	20,000	18	35	259	—	—	—	—	—	—	—	—	F.W. & PROCESS
	ST PAUL SCHOOL	2-150	1 CYL.-REAC.	3600		165	366	—	—	20 LB		—	—	—	—	—	—	—	—	—	—	—	—	—
	VISCOSE	2-5000 2-400	1 CYL. B.P. BLEEDER	3600 3600		435	608·5	—	—	2" 16.5	132,000	—	—	15.0	446.5	16.5	270.4	—	—	—	—	—	—	F.W. & PROCESS
	NEW HAVEN P. & BD. CO.	1-2000	B.P. BLEEDER 1 CYL. IMPRE.	3600	37	370	700	—	—	40 ABS.	53,000	8,000	15.1	80	470	—	—	—	—	—	—	—	—	PROCESS
	HARRIMAN	1-1500 1-200	B.P. BLEEDER B.P.	3600 "		240	397	—	—	20 ABS.	65,000 12,500	40,000	61.5	45	275	—	—	—	—	—	—	—	—	F.W. & PROCESS
	CROCKER BURBANK	1-3000 1-1500 1-1000	1 CYL. IMPULSE REACT.	3600	16 17 13	390	650	—	—	45 ABS.	81,000 46,000 20,000	—	—	—	—	—	—	—	—	—	—	—	—	
	AM-BEMBERG	2-750 1-1500	B-P. IMP. MXD. & EXT.	3600		250	526	—	—	20 ABS. 2"		—	—	20	—	—	—	—	—	—	—	—	—	F.W. & PROCESS
	CHAMP INTER	—									FUTURE													
	MIAMI COPPER CO	1-12,500	1 CYL. IMP. REAC.	1500	27	415	650	—	—	1	180,000	40,000	22,2	110	465	4 0	385	—	—	5.5	170	—	—	F.W., EVAP. & PROCESS
	AMERICAN GLANZSTOFF	2-3000	IMP. REAC. 1 CYL.	3600	13	285	700	—	—	2 1/2"	98,820	90,000	91	40	300	—	—	—	—	—	—	—	—	F.W. & MILL PROCESS

A-ESTIMATED B-PRESS. & TEMP. FOR 150,000 KW.

In all types of plants, the amount of steam being bled is increasing, this increase being greater in the case of the 1200-lb. plants which extract almost a third of the total steam flow to the throttle at full load. This percentage varies with the load, of course, Fig. 19 of the previous article showing the variation in the percentage of steam extracted from a 75,000-kw., 315-lb. turbine for heating its own condensate in two stages.

Industrial plants are making wide use of back pressure and extraction turbines and marked improvements in the smaller machines have been made to meet the requirements of this service. Cross compound turbines have appeared in the industrial field at the Gulf States Steel Co. plant. These units were made by adding new 415-lb. high-pressure elements exhausting into old low pressure turbines that formerly took the exhaust from mill engines.

In the central station field, the addition of a high-pressure turbine exhausting to one or two existing medium pressure turbines is considered as an extremely

used with two rows of velocity compounded blading to take care of the large drop in the first pressure stage. The high-pressure elements for all types are designed for 3600 r.p.m., raising the limit of 3600-r.p.m. machines to 10,000 kw.

POWDERED COAL actually remains in the furnace a comparatively short time. In a furnace burning 1 lb. of coal per cubic foot of effective combustion space, about 13 cu. ft. of gases pass through each cubic foot of combustion space each hour. With a mean temperature of about 2100 deg. F., this time is about 4.3 sec.

Velocity, of course, depends not only on the time in the furnace, but on the shape of the furnace volume as well. If the mean path of the flame is about 30 ft., the average velocity is about 7½ ft. per sec.

BORINGS OR TEST PITS should always be made before deciding on the foundation design of a large power plant.

Condenser Practice Shows Little Change

WELDED CONDENSER SHELL AND USE OF TWO EXPANSION JOINTS ALLOWING SEPARATE SUPPORT OF CONDENSER OUTSTANDING DEVELOPMENTS

LITTLE CHANGE has been made in condenser practice during the past year. The most significant development announced this year has been the introduction of the welded condenser shell into this country at the Parr Shoals Station.

This is a 27,000-sq. ft. heart shaped design with the welded shell built and supported independent of the tubes, tube sheets and water boxes. Tubes are rolled into both tube sheets. One water box is supported on a fixed base, the other on a sliding base to allow for expansion. Rubber expansion joints are used between the shell and each water box to allow for a slight

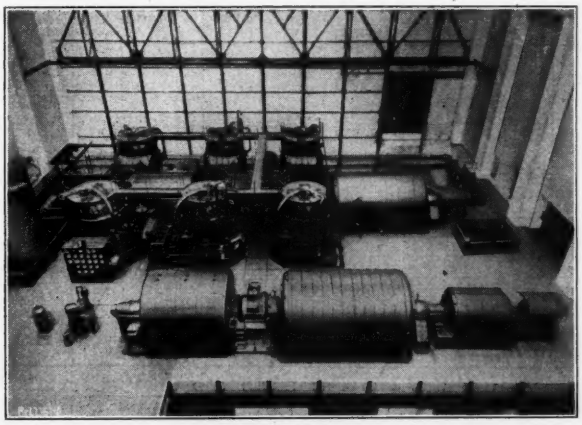


FIG. 1. VERTICAL CONDENSERS USED WITH THE NO. SIX 104,000-KW. UNIT AT CRAWFORD AVENUE STATION

movement in any direction. Support plates in the condenser prevent sagging of the tubes and transmit some of the weight of the tubes and water in these to the shell.

The copper-steel shell $\frac{7}{16}$ in. thick is less than half the usual cast iron thickness for the same service. Copper-iron tube sheets $1\frac{1}{4}$ in. thick are used with $\frac{3}{4}$-in., No. 17 B.W.G., Admiralty tubes. The shell is divided into horizontal sections for cleaning.

Much the same arrangement is used on the 42,500-sq. ft. Deepwater condensers made with the conventional cast iron shell but with vertical instead of horizontally divided water boxes. Tubes are rolled at both ends. The use of the divided water box, however, made the usual floating tube sheet impractical so that the water box is bolted directly to the tube sheet as at Parr Shoals and the two supported on roller bearings. The expansion joint between the shell and tube sheet is a thin metal ring.

At Cahokia the condenser for the 75,000-kw. turbine is built with two expansion joints to allow the condenser shell and water in the tubes to be supported independent of the turbine foundation. This was necessary in order to keep from overloading the foundation piling.

Space limitations at Hell Gate necessitated another novel arrangement. Each of the 137,500-sq. ft. condensers serving the 160,000-kw. turbines are divided into two sections with the water box in the middle. Water enters through pipes under the floor and since they are double pass, leaves from the top of the same box. An external air cooler section and three stage ejectors are used.

At State Line, eight vertical single pass units are used with the two low pressure elements of the 208,000-kw. turbine. These condensers are shown in the headpiece on page 1350. Each unit has a surface of 22,000 sq. ft., giving a total surface of 175,000 sq. ft. for the turbine. The design is somewhat different from the six vertical units used with the 104,000-kw. unit No. 6 at Crawford and shown in Fig. 1.

At Crawford, the incoming water passed upward through a single passage in the center of the shell and downward in a single pass through the tubes. At State Line the water passes upward through the tubes and downward through passages cast integral with the shell.

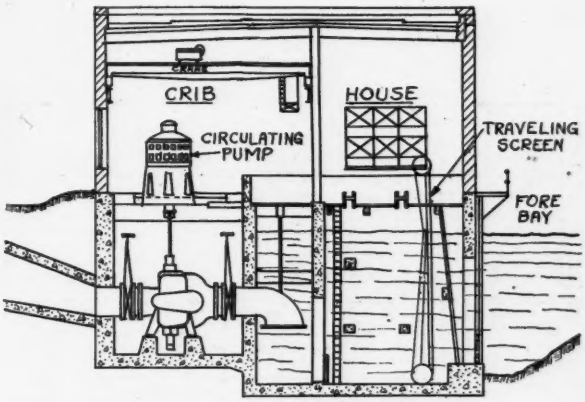


FIG. 2. VERTICAL CIRCULATING PUMPS AS USED AT STATE LINE

Condenser surface per unit of capacity continues to decrease slowly. East River, with 0.56 sq. ft. per kw., is the lowest figure to date and the condensation of 15.50 lb. of steam per sq. ft. of condenser surface is not likely to be exceeded for some time in central station practice. With the industrial plant, figures of surface per unit of generating capacity or condensation per unit of surface have little or no significance.

Turbines and condensers there are selected with the intention of operating in connection with the process extraction load and in most cases the condenser is little more than emergency equipment installed to take the surplus steam that would otherwise be wasted to atmosphere. When the process steam load is off the electric load is also off, so that the condenser is seldom if ever called upon to handle the maximum steam flow to the turbine necessary to carry full electrical load.

Single pass and double pass type condensers are about evenly divided and although the tendency is to use more water with single pass units the difference in circulating pump capacity installed is not particularly noticeable, a figure of 1 g.p.m. per kw. of capacity being a fair figure for high pressure units.

Vertical circulating pumps have not been adopted as widely as conditions two or three years ago seemed to indicate. They were, however, used at State Line, Fig. 2 being a cross section through the screen house.

With the exception of minor improvements there is, as a rule, little new or novel about screen house design but the Ohio River Station has utilized a practical method of increasing the screen capacity as shown in Fig. 4. Water enters the screen through both sides and the bottom and leaves through the space between the descending and ascending screens. This more than doubles the capacity of the screen as conventionally installed with the water flow straight through both sides.

Hotwell pumps are invariably installed in duplicate, each pump having a capacity sufficient to handle the maximum flow from the turbine. With the large units with steam flows upward of 1,000,000 lb. of steam per hour, single pumps are somewhat larger than considered advisable and three or more units are commonly employed, one being a spare, the remaining two being operated in parallel.

State Line uses six such pumps and a rather novel separate hotwell arrangement. A surge tank just ahead of the No. 5 extraction heater taking the load fluctuations and so arranged that the flow in and out is controlled by float valves in the condenser hotwells. Make-

CONDENSERS & AUXILIARIES

	NAME OF STATION	SURFACE PER TURBINE SQ FT	SQ FT/KW	STM. FLOW TO COND. LB/HR	LB/HR/SQ	PASSES	TUBES	PACKING	CIRCULATING PUMPS NO.	CAPACITY EA. G.P.M.	DRIVE	G.P.M. PER KW.	STEAM RATIO #H.O/STM.	COND. PUMPS NO	CAP. LB/HR	DRIVE	VAC. PUMPS NO	TYPE	TOTAL CAP. CU.FT.	SOURCE OF AUX. POWER
CENTRAL STATIONS	DEEPWATER	42,500	0.80	332,000	7.80	1	7735-7/8" 18 B.W.G. ADM. 24'-2 1/2" L.	ROLLED	2	35,500	2300 V. 2 SPEED IND. MOT.	1.34	107	2	450 000	550 V CONST. SPEED	1	STM. JET	39	TRANS.
	HOLLAND	31,600	.566	339,900	10.75	1	7310-3/4"-17 B.W.G. 22'-0" L.	ROLLED	2	27,900	IND MOT	1.00	82	2 2	350 000 450 000		2 2	R.D.V. STM-JET		TRANS.
	STATION A	34,000	0.68	390,000	11.48	2	7/8" 16 B.W.G. 22' LONG	ROLLED		34,000 B	MOTOR	—	—	2	450 000	2300 V. VAR. SP.	2	STM-JET	44	TRANS.
	* HELL GATE 29 30	A 137,500	0.83	1,469,605	10.70	2	32,084 1/8" 18 B.W.G. 17'-6"	1 ROLLED 1 PACKED END	2	77,500	2300 V 500 HP 2 SPD IND	0.94	54	3	875 000	100 HP 2300 V. IND. MOT. 870 R.P.M.	1	3 STG. STEAM JET	83.6	HSE. GEN & TRANS
	EAST RIVER ADD. *	90,000	0.58	1,397,200	15.50	1	15,100 7/8" 18 B.W.G. 26' LONG	1 ROLLED END 1 PACKED END	2	80,000	800 H.P. NON.CN. TURB	1.00	57	3	700 000	75 HP 1200 R.P.M. NON.CON. TURB.	1	STM-JET	75	STEAM
	STATE LINE	176,000 (8 UNITS)	0.88	1,961,000	9.45	1	7/8" 18 B.W.G. 20'-2 1/2" L.	1 ROLLED 1 PACKED	4	95,000	600 H.P. 2200 V. MOTOR	1.90	97	6	500 000	250 HP 2200 V. MOTOR		STM-JET		SHAFT GEN.
	* CAHOKIA	80,000	0.80	833,000	10.57	2	13,100 7/8" 18 B.W.G. 20'-2 1/2"	1 ROLLED 1 PACKED END	2	35,000	2300 V 2 SPD. IND.	0.93	101	2	750 000	2300 V VAR. SPEED	1	R.D.V.	40	HSE. TUR.
	DELRAY	60,000	1.20	451,000	7.51	1	8350-1" 18 B.W.G. ADM. 24' L.	1 ROLLED 1 PACKED END	2	60,000	VAR. SPEED D.C.	2.40	133	2	750 000	1 D.C. 1 S.D.	1	R.D.V. 2 STGE 1 CYCLE	9.4	AUX. D.C. TURBO GEN.
	OHIO RIVER	H-16,500 H-15000 C	2.2 1.2	79,000 112,000	4.80 7.50	2 2	2860-1" O.D. 18 B.W.G. ADM. 20' L.	1 ROLLED 1 PACKED 2 ROLLED	1 2	12,500 9,500	150 HP (100 " 440 V. IND. M	1.67 1.52	79 85	2 2	175 000 "	20 HP 25 " 440 V.	1	2 STGE 3 " STM. IND. MOT.		TRANS.
	GORGAS #2	70,000	1.17	499,000	7.14	2	12300-1" 18 B.W.G. 22' LONG	1 ROLLED 1 PACKED END	2	44,000	2300 V. 1 SPD. IND.	1.48	88	2	605 000	2300 V VAR. SPD MOTOR	1	2 STG. STM. JET		TRANS.
	RIVERBEND	60,000	1.09	451,530	7.53	2	9750-1" 18 B.W.G 23'0" LONG	1 ROLLED 1 PACKED END	2	36,000	300 R.P.M. SQ. CGE CONST. SPEED	1.31	80	2	547,000	2300 V SQ-CGE-	2	STEAM JET		TRANS
	* ENGLISH ADD	20,000	1.8	145,000	7.25	2	1" 18 B.W.G. ADM. 18'-2 3/4"	PACKED	1	34,400	GEAR TURB	1.95	85	1	234 000	TURBO GEARED	1	R D V	102.5	STEAM
	FREMONT *	4,200	1.88	30,000	7.15	3	3/4"-13 LONG	PACKED	1	25,000	2300 V.	1	2.5	2	50 000	2200 V	1	ST-JET	24	TRANS.
INDUSTRIAL PLANTS	WAUKEGAN N.S.C. & C. CO.	1260	1.88	11,600	9.21	2	69-2 3/4" 18 B.W.G. MUNTZ 10'	PACKED	1	1,300	440 V. IND	1.73	57	2	15 700	1 MOT. 1 TURB.	1		—	STM. & TRANS.
	ST. PAUL'S SCHOOL	—									NONE									
	VISCOSE	7,000	1.4	87,000	8.15	2	3/4" 18 B.W.G. 14' LONG	PACKED	2	9,000	150 HP 440 V. MOTOR	.65	128	4	65 000	440 V.	2	ST-JET	51.3	TRANS.
	NEW HAVEN P & BD. CO.	—									NONE									
	HARRIMAN	—									NONE									
	CROCKER BURBANK	—									NONE									
	AMERICAN BEMBERG	1770	1.18	25,000	1442	1	885 3/4" OD	PACKED	—	B	440 V. IND.	—	119	2	25000	440 V. IND.	2	STM. JET	6.8	TRANS.
	CHAMPION INTERNAT'L	—									FUTURE									
	MIAMI COPR CO.	24,500	1.86	140,000	5.72	2	5200 1/8" 16 B.W.G COPPER	ROLLED BOTH ENDS	—	B	6600 V. MOTOR	—	81	2	210 000	440 V.	2	STM. JETS	26.7	TRANS.
	AMERICAN GLANZSTOFF	2,100	0.7	36,800	17.40	1	804'-5/8" OD 18 B.W.G. ADM. 16' L.	1 ROLLED 1 PACKED END	2	2000	440 V. IND. MOTOR	75	.55	2	40 000 EACH	1 TURB 1-440 V. IND. MOT	1	STM JET.	6.9	TRANS.

A - INCLUDES 9,000 SQ. FT. EXTERNAL AIR COOLER.
B - SUPPLIED FROM A SYSTEM CONN. TO ALL UNITS
* EXTERNAL AIR COOLER
C THE 18 800 SQ FT COND SERVES THE 75000 KW TURBINE. BOTH PIECES OF EQUIPMENT WERE PURCHASED 3 YEARS AGO FOR ANOTHER STATION.

up is introduced in the hotwell and separate deaerating heaters eliminated in layout.

Motor drive of auxiliaries is used in practically all stations, East River being one large station that has consistently used and continues to use steam turbine drive. As a rule, one boiler feed pump is the only plant auxiliary universally steam driven although a number of stations, including many of the industrial plants, use

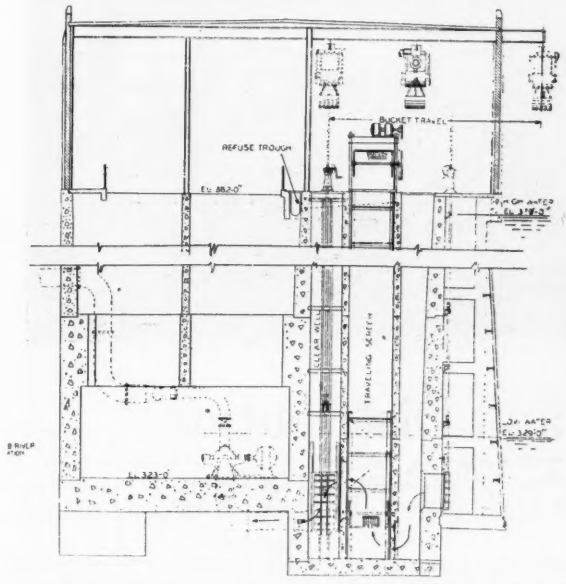


FIG. 3. TRAVELLING SCREEN ARRANGEMENT WHERE WATER ENTERS AT BOTH SIDES AND BOTTOM TO GIVE INCREASED CAPACITY

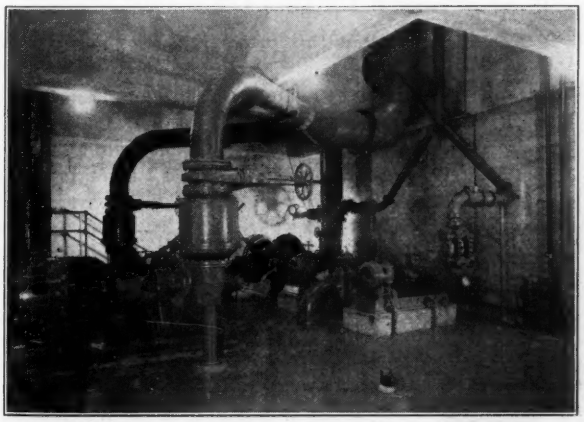


FIG. 4. ARRANGEMENT OF CIRCULATING AND SERVICE WATER PUMPS AT OHIO RIVER STATION

duplicate steam and electric drive for some of the more essential auxiliaries both for reliability and heat balance purposes.

The tendency is toward the unit system with each generating unit and its essential auxiliaries forming a complete unit which is operated as such. Station A and Miami Copper are two stations where this is not done, both stations have common circulating water supply systems. Many stations, however, have cross over connections so that in an emergency circulating water from one unit can be used in another. Ohio River Station is a good example of this.

House turbines and shaft generators are still widely used although the tendency toward supplying at least a portion of the auxiliary load through transformers seems to be increasing. As the auxiliary load grows, that is, as the size of stations increases, the house generator may again become of greater importance because the steam rates, especially if 3600 r.p.m. is used, are good and this materially lessens the advantages of shaft

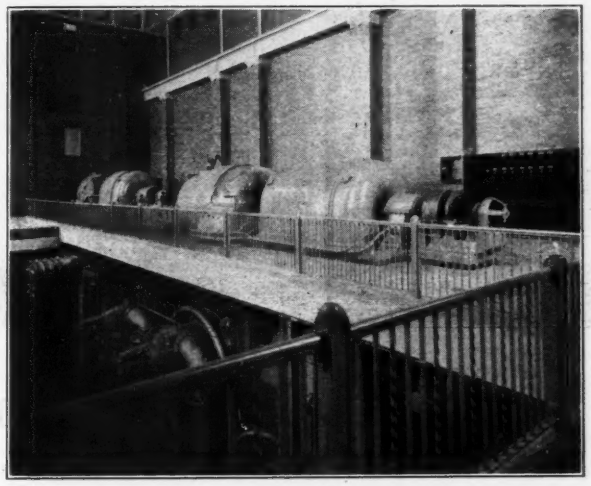


FIG. 5. CONDENSER INSTALLATION ARRANGED SO AS TO BE ASSEMBLED FOR REPAIR AND INSPECTION

generators. At Station A the house turbine is driven by the exhaust of the high-pressure element and exhausts in turn to the high-pressure heater.

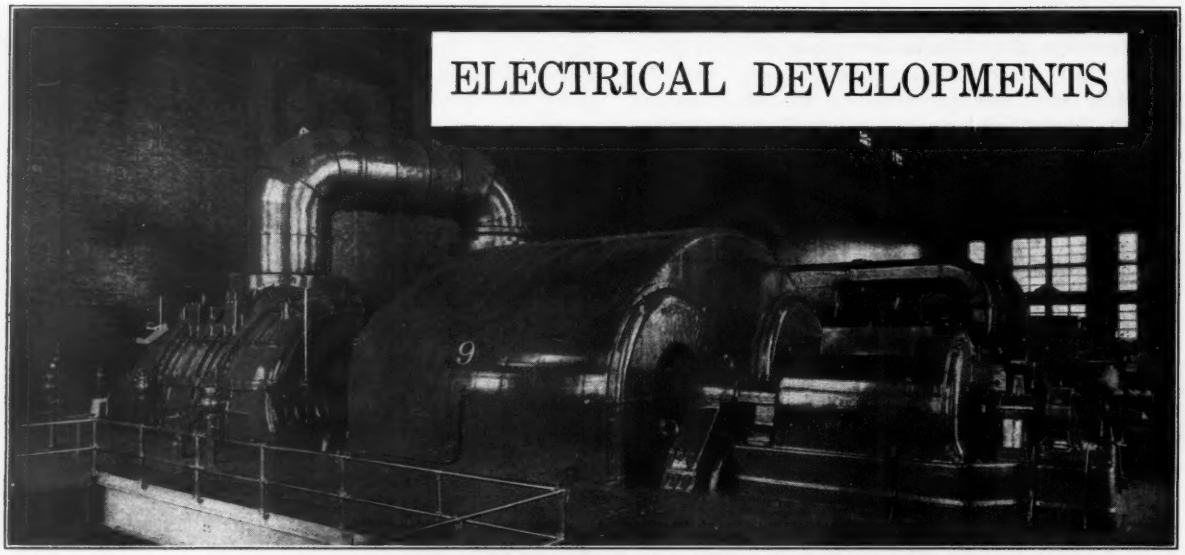
Direct-current motors lend themselves well to speed control but are not widely used because, as a rule, the added complications of the two systems are not felt advisable. For the usual plant, 2300 v. seems to be most widely used, except in the smaller sizes. Some engineers, however, do not favor the many oil switches involved with 2300 and higher auxiliary voltages and favor 440 v.

Centralization of control is being carried forward to greater lengths than before but not without opposition. Many engineers feel that control at the machine is advisable, giving increased safety to both equipment and operator. Increased personnel is necessary but such labor is usually available for periodic inspections. Local control reduces the possibility of starting a machine while men are working on it and also the possibilities of starting defective equipment.

Steam Economy in the Beet Sugar Factory

OUR ATTENTION has been directed to an error which occurred in the article under the above title which appeared on page 1278 of the December 1 issue. In Table II, showing the heat use in the 1928 campaign, the notations D-5; N-5; K-5, at the bottom of the tabulation, should read D-J; N-J and K-J to correspond with the same items in the left-hand column.

THE WATER WORKS industry is said to be the oldest known public utility.



Electric Generation and Distribution

NEW HIGH-SPEED BREAKERS, IMPROVED FAULT GROUND BUS, HIGH VOLTAGE CABLES, VERTICAL A.C. NETWORK, FEATURES OF YEAR'S DEVELOPMENT. BY H. W. EALES

IN REVIEWING the electrical developments of the year, we find that 220,000 v. (nominal) is still the maximum voltage of alternating-current transmission lines in operation. At the moment, this appears to be the maximum practicable commercial voltage. We shall follow, therefore, with more than ordinary interest, laboratory research in the amplification of vacuum tube rectifiers for deriving extra high-voltage direct-current transmission systems and of the thyratron tube inverting device for converting the high-voltage direct current back to alternating current at the points of use, hints of which have appeared in print from time to time from manufacturers' laboratories. At the present time, such a system is not available on a commercial scale, hence no one can now predict how far such a development may go.

H. W. EALES, FELLOW A. I. E. E,
Chief Electrical Engineer
Byllesby Engineering & Management Corporation, Chicago, Ill.

In the meantime, enough protests have been voiced by users to indicate that the development of extra high-voltage switchgear and its attendant protective devices has hardly kept pace with the rapid development in prime mover equipment and in high-voltage alternating-current transmission. Complaints have been made that oil type circuit breakers on 220-kv. systems have been so sluggish in their operation that in times of trouble the system has become dislocated with consequent impairment of service. A most urgent need has been expressed during the past two years for a circuit breaker of interrupting capacity of from 2,500,000 to 3,000,000 kv-a., which would also interrupt the fault current with sufficient rapidity so that the stability of the system can be maintained. The suggestion has been made that perhaps the possibilities of new forms of breakers other than the oil type breaker be investigated, such as vacuum tube breakers, etc.

It would appear that this prayer has, in part, been answered. Announcement was recently made of the completion of manufacture of a 2,500,000-kv-a., 220-kv. circuit breaker which was tested under short circuit conditions on one of the large 220-kv. systems, and which successfully interrupted short circuit currents in a period of six cycles—on a 60-cycle system—i.e., within one-tenth of a second. This time of opening is less than one-third of the previous fastest operation of circuit breakers of this general type.

It is impossible to overestimate the improvement in system stability and service reliability, which should result from the application of these higher-speed breakers.

Another development of far-reaching importance—described in a paper before the American Institute of Electrical Engineers—is the construction of a considerable number of the so-called "non-resonating" high-voltage transformers—constructed so far for systems of 132 kv. and above—and in which the transformer windings are protected by special insulated shields which act to distribute transient voltages of the system over these windings and thus protect them

against electrical failures during such transient disturbances.

In the generating plant, there seems to be no particular limit of size of generators which can be manufactured. Stated in the broadest terms, it would appear that the manufacturers will undertake the design and manufacture of any size generating unit which a purchaser will buy. In the fall of the present year, there were placed in service a 160,000-kw., single shaft tandem compound, 25-cycle turbo-generator unit at the East River Station of the New York Edison Co., and a 75,000-kw., single shaft, single drum, 1800-r.p.m., 60-cycle unit at the Cahokia Station, St. Louis. Both of these units were equipped with double winding armatures each representing the largest generator of its type placed in service to date.

The following summarizes the advantages claimed for this type of generator:

1. Reduction in magnitude of short circuit current at times of fault.

2. Maintenance of higher bus voltage during fault conditions.

3. Reduction in capacity of generator oil circuit breakers, disconnecting switches and reactors.

4. Elimination of bus reactors by connecting the two windings to adjacent split bus sections, power flow between sections being obtained by transformer action between the two windings.

For further information the reader is referred to exhaustive paper on this subject, presented at the Great Lakes District Meeting, American Institute of Electrical Engineers, in Chicago, December 2-4, 1929.

Increases in size of turbine and boiler units in modern steam power plants, together with the numerous mechanical refinements to procure improvement in the net economic thermal efficiency of the station, have imposed new burdens upon the electrical power supply system for the station auxiliaries. This system must be reliable, flexible and simple.

It is now customary to divide the pumping burden for circulating water for the condenser on two pumps. The interrelation of the water, fuel and draft requirements permits of certain grouping and interlocking of the circuits for the motors driving these boiler-room auxiliaries. Advantage should be taken of these relationships in the design of the electrical system.

One treatment of the problem consists in dividing the auxiliary power supply—usually 2300 v.—for each turbine unit together with its complement of pumps and boilers into two parts and to carry one-half of all the auxiliaries on each part. Thus a major failure on each part will at most cripple one-half of the capacity of the turbine unit. With such an arrangement, one part of the power supply is obtained from a transformer directly connected to the generator leads and the other part of the supply is obtained from a transformer supplied from the station generator bus. The use of interchangeable truck type, circuit breaker units one per circuit—with suitable spare units—gives sufficient flexibility for the needs of maintenance and inspection.

Principles of station auxiliary power supply system, as above generally described, have been adopted in the James H. Reed power station of the Duquesne Light Co. now under construction on Brunot Island, Pittsburgh, in which the first 60,000-kw. turbine unit is now being erected.

Use of surface air coolers for closed system of ventilation of turbo-generators has now become such standard practice on all units of any appreciable size that the application has ceased to be a novelty.

One development which has met with considerable favor during the year, is the use of a pilot exciter or as called by some, a sub-exciter, mounted on the end of the generator shaft in addition to the shaft-driven exciter, and used for the purpose of separately exciting the exciter. This arrangement results in higher speed response in the excitation circuit and also permits the omission of generator field rheostat and of its considerable losses. In addition, it also results in reduced cost of the installation.

During the summer of the current year, the new State Line Plant of the State Line Generating Company, located on Lake Michigan, near the boundary line of the States of Illinois and Indiana, was placed in commercial service. The generators in this station were wound for operation at 22,000 v., representing the highest voltage modern generators placed in service in this country. Approximately a year ago, installation was made in a new power station at Brimsdown, North London, England, of a 25,000-kw., 33,000-v., 3000-r.p.m. turbo-generator unit. All reports to date indicate the successful operation of all of these units.

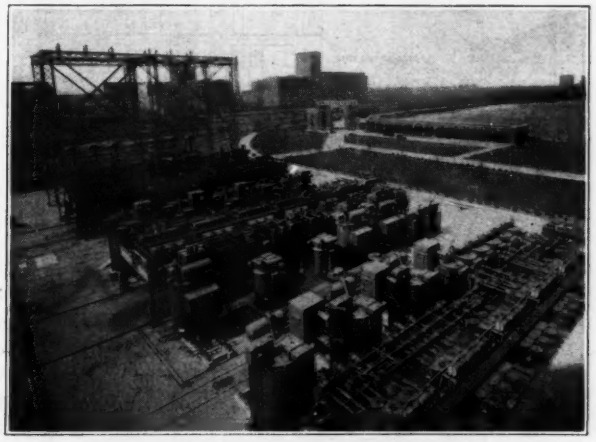


FIG. 1. OUTDOOR BUS AND SWITCHING SYSTEM AT STATE LINE STATION

The 22-kv. connections at the State Line Plant represent a noteworthy achievement in this country. The entire 22-kv. switch and bus system is located outdoors and consists of a novel totally enclosed metal clad oil filled arrangement, with no exposed live parts, as shown in the accompanying photograph.

Fault Ground Bus Performance

It is interesting to record a report from the Duquesne Light Company of the successful functioning of the fault ground bus in the new isolated phase switchhouse on Brunot Island. During the last operation of connecting a section of bus—in a newly-built switchhouse addition—to the older bus section, one of the construction electricians came in contact with a live part starting an arc to ground. The protective equipment

on the fault ground bus caused the automatic de-energizing of the new section of the switchhouse so rapidly that the workman's life was saved and the damage to the equipment was trifling. A complete description of the Brunot Island switchhouse and its fault ground bus will be found in a paper presented at the American Institute of Electrical Engineers, Great Lakes District Meeting, in Chicago, December 2-4, 1929. The accompanying cuts illustrate the fundamental principles of the application.

Metropolitan System Operation

One of the outstanding announcements of the year was contained in a group of papers constituting a sym-

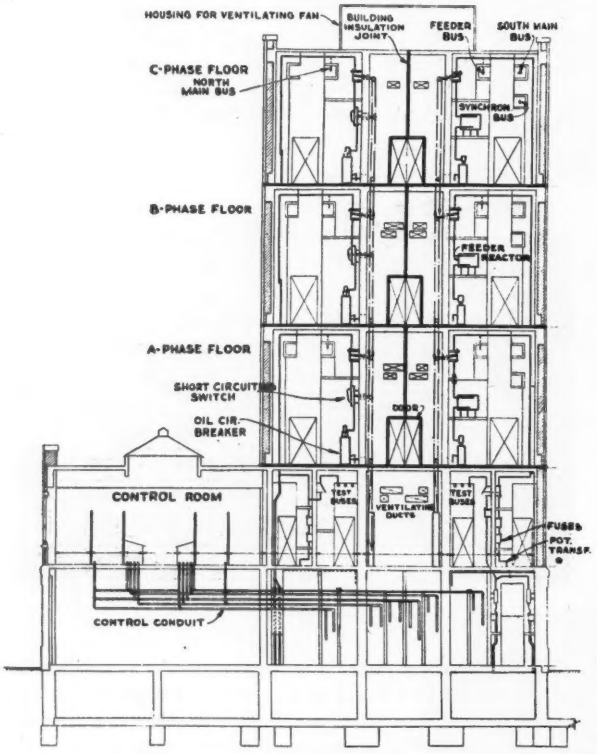


FIG. 2. SECTION THROUGH BRUNOT ISLAND SWITCH HOUSE SHOWING BUILDING INSULATION JOINTS

posium on the subject "Synchronized at the Load," which was held at the American Institute of Electrical Engineers' summer convention at Swampscott, Mass. The recommendations of the symposium were for the establishment of a "loose coupled" generating and transmission system. This recommendation covered the operation of the several power plants connected to the transmission system with their respective buses sectionalized and with synchronism maintained between the sections on the low tension side of the step-down transformer banks at the respective substations. In this instance, the point of synchronism is the 4-kv. substation bus, from which feeders supplying the actual load are taken, hence the origin of the term "Synchronized at the Load."

The following advantages are claimed for this scheme of connection:

1. It reduces the magnitude of the short circuit current at times of fault, thus permitting of the employment of less expensive circuit breakers of lower interrupting capacity on new installations, or the postponement of the time of replacement of existing circuit breakers or the installation of additional current limiting equipment. Short circuit tests on an important high capacity transmission feeder from a power station, showed that the instantaneous symmetrical short circuit current on this system was reduced by 40 per cent.

2. It reduces the magnitude of the voltage disturbance, at time of fault, and thus improves the quality of service rendered by the system.

3. It gives greater control of load shifting from station to station, by permitting of more exact control of the flow of wattless current, and thus improves the power station operating economy.

The financial significance of this subject, in the case of the interconnected systems in New York City may, in a measure, be appreciated when it is realized that the total rated capacity of both 25 cycle and 60 cycle of prime mover equipment in routine operation at time of present peak, at this writing, is of the order of 1,800,000 kv-a.

Announcement was made at the symposium, of a bus short circuit on a section of Hell Gate Station, which had occurred a day or two previously, and which was successfully cleared by the station breakers with the disturbance hardly noticed on the outside system. It is understood that within the past few weeks a fault at the Sherman Creek Station bus was successfully cleared without distress of the breakers, and with negligible voltage dip on the outside system.

Experience with High-Voltage Cable

The year just closing, marks the end of a 2½-yr. period of most successful operation with the 132,000-v. underground cable installations in New York City and Chicago. The remarkable report has been received that the original six-mile, three-phase circuit consisting of 18 mi. of single conductor, oil-filled cable in Chicago, and the 12-mi., three-phase circuit consisting of 36 mi. of single conductor, oil-filled cable in New York City, have operated to date, without a single electrical failure. There have been some minor difficulties with oil leakages, but these have been so gradual and small in extent, that there has been ample time to make the necessary repairs at times when the cables could be conveniently removed from service.

Experience has shown that the location of oil leaks may be most readily detected in a practical way by pulling in lengths of rope in empty ducts under the ducts carrying the oil-filled cable, and it is well to keep this fact in mind when designing the duct system.

During the past few weeks, the New York company has installed a second 12-mi. circuit, paralleling the first one above mentioned. It is understood that experience with the first cable has demonstrated the desirability of installing a somewhat greater number of stop joints than were installed in the first cable, and that this has been done in the new cable installation and that after the new cable was placed in service additional stop joints have been placed in the earlier cable.

Inquiry of cable manufacturers who have furnished portions of the New York and Chicago 132-kv. cable, indicates that at least one manufacturer is prepared to

furnish cable for operation at 220,000 v. with grounded neutral.

During the past year, orders were placed for eight 4000-ft. lengths of 750,000-c.m. shielded type single conductor paper insulated leaded cable with wire armor finish for submarine use at a depth of 50 to 60 ft. in crossing the Delaware River. Six of these cables are to constitute two 60,000-kv-a. rated capacity 66-kv. circuits, with the other two cables as spares. This represents the highest voltage submarine cable so far attempted.

Inquiry of cable manufacturers also revealed that the present tendency, with respect to 3-core cables, 22 kv. and above, is to use cables of the shielded type. This shielding consists of copper tape wound about each of the single conductors in the cable. Experience has demonstrated that this type of cable has superior electrical characteristics and that it may also be operated

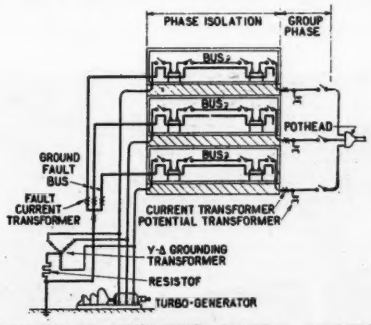


FIG. 3. DIAGRAM SHOWING FAULT GROUND BUS AT BRUNOT ISLAND

at substantial increases in load over the cables of non-shielded type.

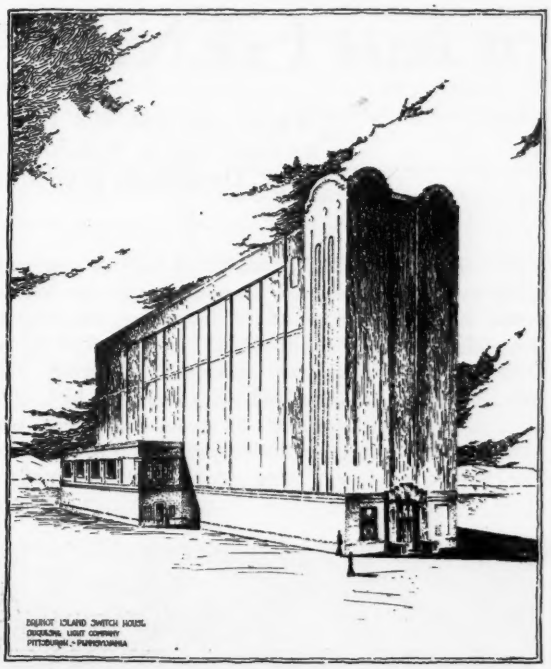
Hydrogen Cooled Equipment

At the 1929 American Institute of Electrical Engineers' summer convention, a paper was presented on installations of outdoor type hydrogen cooled synchronous condensers, one of these being a 12,500-kv-a. unit at Pawtucket, Rhode Island, and the other a 20,000-kv-a. unit at Charleston, West Virginia. The operation of the units was reported as entirely successful with small hydrogen leakage. It was then reported that three additional 15,000-kv-a. hydrogen cooled units were under construction.

One manufacturer of turbo-generators has stated that he considers that hydrogen cooling of turbo-generators is entirely practicable, and that he is prepared to quote on a maximum size 1800-r.p.m. hydrogen cooled generator of approximately 172,000-kv-a. capacity, and further states that this same machine would have a rating of 137,500 kv-a. if operated with air cooling.

Limiting Direct-Current Load—New York City Supplying Very Tall Buildings with Alternating Current

Finding that the load of the direct current distribution system on Manhattan Island had reached the enormous value of 400,000 kw. and in the face of a very rapid increase in this load, the New York Edison Co. announced that no further extension of the direct current system would be made and that all new connections and buildings would be supplied with alternating current. In view of the fact that there were several of the very tallest buildings thus far attempted, then in the process of construction,—one of them being approximately 70 stories tall—it is evident that this decision



was one of considerable moment. Some comprehension of the magnitude of the problem may be had when it is realized that the total capacity of the transformers installed in the 70-story building mentioned, will be of the order of 3000 kv-a. The scheme of power supply adopted consists of bringing probably four 3-conductor, 3-phase, 13,200-v. system underground cables up to several floors in the structure. On each of these several floors will be located several banks of transformers supplying secondary low tension 208/120 Y connected grounded neutral 3-phase alternating current networks, which will extend vertically up and down the building to the remaining floors. Low tension energy delivered will be metered. The power company will supply, own and maintain the high tension cables, transformers and network protectors and the building owners will supply the transformer rooms. Switching of the high tension supply will be carried out at the power company's substations and the network protectors will function to clear the network from any faults developing in the high tension supply.

Low Tension A.C. Street Networks

Low tension a.c. networks begun several years ago in Pittsburgh, Minneapolis and Oklahoma City were materially extended during the past year. Report has also been received of the initial installation during the year of similar comprehensive low tension networks in Louisville and St. Paul. These systems, together with description of important tests on burning off faults from low tension alternating current networks, have been recently described in a paper presented at the American Institute of Electrical Engineers' District Meeting, in Chicago, December 2-4, 1929.

LARGE UNITS *continue to mark* GENERATOR PROGRESS

While the 160,000 Kw. Electric Generator installed at East River Station was the largest unit built this year, Designers predict still larger units for the future

INCREASE IN THE capacity of turbine generators still continues to be the most impressive development in the art of electric generator design and construction, although the year's progress has been marked by several other achievements of scarcely less interest. Compared to the rather animated controversies which invest the design of and operation of steam equipment, progress in electric generator design proceeds quite smoothly. The future course of generator practice usually is more clearly defined than future progress in steam generating practice and thus far the electrical engineer has been able to keep just a little ahead of the steam turbine designer. Whenever a new larger turbine was proposed, the electrical engineers were ready with the designs for an electric generator to meet the turbine requirements.

FIG. 1. COOLER CASING OF THE 160,000-KW. EAST RIVER GENERATOR (PHOTO, COURTESY GENERAL ELECTRIC CO.)

As may be noted from the accompanying tabulation on Electric Generator Practice, the tendency in nearly all of the central stations is towards large units, units in excess of 50,000 kv-a. being quite common. The largest generator installed this year is the 160,000-kw. (unity power factor) unit for the East River Station of the New York Edison Co. This is the largest generator ever built, being driven by a tandem-compound turbine. The next largest generators are the two 80,000-kw. machines connected to the 160,000-kw. cross compound turbine at Hell Gate station. These generators, however, are not as large as the 94,000-kw. unit installed at Long Beach Station No. 3, last year.

The construction of the 160,000-kw. unit for East River Station presents a number of interesting constructional features. The frame is made entirely of steel plate, welded, and represents the most approved practice in construction. The nonmagnetic steel clamping flanges at the two ends of the stator and the cast iron end shields are the only castings in the generator proper. The employment of steel plate and the application of welding have resulted in marked reduction in weight and at the same time resulted in a much stronger construction than would have been possible with a fabricated cast iron structure as formerly built. As an example of this weight reduction, a recent design of frame on a 75,000-kv-a. generator showed practically the same weight as the frame of a 37,500-kv-a. generator of an earlier design in which castings were employed.

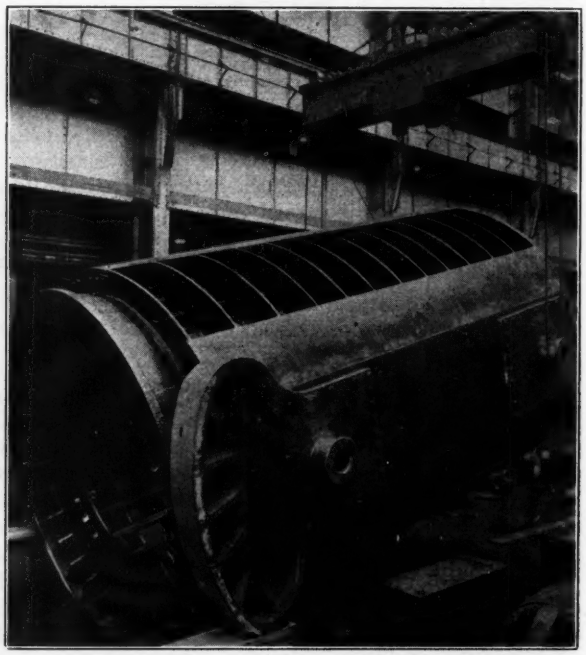


FIG. 2. STATOR FRAME WITHOUT PUNCHINGS, OF THE EAST RIVER UNIT, SHOWING SPECIALLY DESIGNED TRUNNIONS FOR HANDLING

Owing to the physical dimensions of the 160,000-kw. generator and the enormous weight, the stator of this unit was built at East River Station. Specially designed trunnions were necessary in order that the frame, after it had received its load of half a million pounds of laminations could be turned from a vertical to a horizontal position on its base. (See Fig. 2.)

The body portion of this machine alone weighs

228,000 lb. and was the largest single forging ever turned out by the steel mills. This forging involved the use of a billet weighing 465,000 lb. The completed rotor of this unit weighs 290,000 lb. (145 t.) and this mass revolves at the rate of 25 revolutions per second, (1500 r.p.m.)!

While no units larger in capacity than this 160,000-kw. generator are contemplated, the designers seem confident that larger units can be built if necessary. The 160,000-kw. East River machine is a 25-cycle unit and two-winding arrangement. The machine has two circuits entirely separate from each other and coupled only by the mutual reactance between them. These windings are connected to separate bus sections whose only tie normally is through the transformer action of the two windings in the generator. The advantages of the two-winding generator include the use of smaller switches, a bus arrangement whereby short circuit disturbances are localized and minimized, and less switch house building space. A ground on one winding will not require

ELECTRIC GENERATOR PRACTICE

	NAME OF STATION	MAIN GENERATING UNITS: CAPACITY	NUMBER OF ELEMENTS	SPEED	VOLTAGE	VOLTAGE REGULATION	EXCITATION: TYPE EXCITERS	EXCITATION: CAPACITY	EXCITATION: EMERGENCY EXCITATION	COOLING SYSTEM: TYPE COOLER	COOLING SYSTEM: TYPE	COOLING SYSTEM: TEMP. AIR IN	COOLING SYSTEM: TEMP. AIR OUT	HOUSE SUPPLY: METHOD USED	HOUSE SUPPLY: CAPACITY	HOUSE SUPPLY: ALTERNATIVE METHOD	HOUSE SUPPLY: VOLTAGE
CENTRAL STATIONS	DEEPWATER	2-62,350 KV-A. 1-15,625 KV-A.	2 EACH 1	3600/1800 3600	11000 11000	AUTO. "	SHAFT	60 KW/250 KW/4 KW 60 KW	M-G-SET	FIN TUBE	CLOSED	149°	98°	FROM GEN. THRO. AUX. TRANSFORMER	3-6000 KV-A	FROM HIGH TENSION BUS THRO. 3RD WINDING ON MAIN TRANSFORMERS	2300 V. 550 V.
	HOLLAND	1-P-1-13850 KV-A L P-1-$1700 "	2	3600 1800	13800 13800	MANUAL	SHAFT & MOTOR	250 KW	M-G-SET	FIN TUBE	CLOSED		40°C	TRANSFORMER ON GENERATOR BUS	3-2500 3-300	TRANSFORMERS FROM 33 KV. SUBSTA.	2300 V. 220 V.
	STATION-A	2-50,000-KV-A.	2 EACH	3600 1800	12000 12000	MANUAL "	SHAFT	250 KW	M-G-SET	FIN TUBE	CLOSED		40°C	AUX. TRANS. CONCTD. TO MAIN BUSES	38500 KV-A		2300 V. 230 V.
	HELL GATE '29/'30	1-194,850 KV-A.	2 EACH	1800	13200	AUTO.	SHAFT	250 KW	M-G-SET	FIN TUBE	CLOSED	* 129°F	* 80°F	HOUSE GENERATORS	1-5000 KW TIED IN WITH AUX. BUS	TRANS. FROM HIGH TENSION BUS	2300 V. 220 V.
	EAST RIVER ADD.	1 180,000 KW	1	1500	11400	AUTO.	SHAFT	250 KW	M-G-SET.	FIN TUBE	CLOSED	135°F	95°F	†	†	†	†
	STATE LINE	1-76000 KW 85% P.F. 2-62000 KW. 85% P.F.	3	1800	22000	AUTO.	SHAFT		M-G-SET	FIN TUBE	CLOSED			HOUSE GEN	2-4000 KW	38000 KW. TRANS.	A 2300 V B 460 V C 230 V 115 V & D.C.
	CAHOKIA	1-75,000 K.W.	2 EACH	1800	13800	MANUAL	SHAFT		STM. & M.G. SET	FIN TUBE	CLOSED		90°F	HOUSE ALTERNATOR	2-2000		
	DELRAY NO 3	2-62500 KV-A	1	1200	12200	MANUAL	SHAFT	300 KW	M-G-SET	FIN TUBE	CLOSED			GEARED D-C. TURB GENERATOR	3-4000	1-300 KW M-G-SET DIR. FROM STA. BUS	220
	OHIO RIVER	1-15,625 KV-A. 1-9,375	1 1	1800 1800	12 500 4000	AUTO	SHAFT	60 KW MIN 4 KW AUX 45 KW MIN 7.5 " AUX	NONE		CLOSED	144.5°	104°	TRANS FROM 12.5 KV STATION BUS	3-750 KV-A 12.5 " 480 V	NONE	——
	GORGAS NO. 2	1-66,667 KV-A	1	1800	13800	AUTO	SHAFT	200 KW	M-G-SET	FIN TUBE	CLOSED	127°	97°	HOUSE SERV. TRANS TRANSMISSION LINE	30000 KV-A.	TRANS. MAY BE SUPP. FROM TRANS. LIN	2300
	RIVER BEND	2 68 750 KV-A	1	1800	13800	MANUAL	SHAFT	200 KW	M-G-SET	FIN TUBE	CLOSED			TRANS. FROM EA. UNIT FOR ESSENTIAL AUX NON ESS. AUX. FROM SEP. BANK	2-7500 1-750	FROM OUTSIDE SOURCE ALSO TRANS. FROM TRANSMISSION LINES	2300 575
	ENGLISH ADD.	2-15 625 KV-A	1	1800	13 800	AUTO.	DUPLEX DR. SER. UNIT	150 KW	STM. DRIV.	FIN TUBE	CLOSED		104°	TRANSFORMERS	2-1000 KW	D.C. SUPPLY 2-25 KW. M.G. SETS	460 V.
	FREMONT	5906 KV-A.	1	3600	2300	AUTO.	1-MOT. GEN 1-TURB. GEN 1-ENG. GEN	35 KW 40 " 20 "	ENGINE & TURB. GEN.	FIN TUBE	CLOSED	85°	68°	FROM MAIN BUS			
INDUSTRIAL PLANTS	WAUKEGAN (NS C & C)	2-937 KVA	1	3600	2300	AUTO.	SHAFT	9 KW	TURB-GEN	NONE	OPEN	——	——	TRANSFORMERS	——	NONE	440
	ST PAUL SCHOOL	2-150 KV-A	1		2300	AUTO.	SHAFT			NONE	NATURL						
	VISCOSE (MEADVILLE)	2-5000 KW 2-400 KW	1	3600 6548	6600 2300	AUTO.	SHAFT SEPARATE	50 KW 20 "	50 KW 20 KW	FIN TUBE	CLOSED	125°	90°	TRANSFORMERS	3-200 KV-A	CITY LINE	2300 460/230/115
	NEW HAVEN PULP & BOARD	1-2000	1	3600	460	AUTO.	SHAFT	18 KW	M-G-SET	FIN TUBE	CLOSED	150°	104°	FROM MAIN BUS			
	HARRIMAN	1-1875 KV-A 1-250 KV-A	1	3600 3600	550 550	AUTO.	SHAFT	35 KW	STM-DRIVEN					FROM MAIN BUS	——	——	550
	CROCKER BURBANK	1-3750 KV-A 1-1875 " 1-1250 "	1 1 1	3600	2300	AUTO.	3 M-GEN'S.	2-30 KW 1-20 KW	M-G-SETS CROSS CONN.	SPRAY AIR WASHER	CLOSED			FROM ONE BUS ON WHICH 1 GEN. IS IN PAR. WITH OTHER SIDE TRANS.		TRANS. FROM TRANSMISSION LINE	2300 220
	AM. BEMBERG	2 937 KV-A. 1 875 "	1 1	3600 3600	440 440	AUTO	SHAFT TYPE MOT. GEN.	30 KW	M-G-SET	FIN TUBE	CLOSED			FROM MAIN BUS		TRANS FROM 2300V TRANSMISSION LIN.	440/110
	CHAMP INT.	* *															
	MIAMI COPPER	1 15625 KV-A	1	1500	6600	AUTO	M G SETS	200 KW	STM. GEN.	FIN TUBE	CLOSED	125	95	MAIN BUSES		BATTERY	
	AM. GLANZSTOF	2 3750 KV-A	1	3600	2300	AUTO.	SHAFT	25 KW		FIN TUBE	CLOSED	151	104	MAIN GEN.		TRANS. LINE FROM AM BEMBERG	2300 440

* TAKEN FROM ACTUAL READINGS
† NO NEW INSTALLATIONS
** NO NEW ELECTRICAL EQUIPMENT ADDED

while it may not be known to engineers other than designers, it is more difficult to design a 25-cycle machine of great capacity than it is a 50-cycle machine of the same speed. According to Foster and Savage,[1] by the introduction of certain features such as hydrogen cooling, a 50-cycle generator, conservative in its temperatures and other important characteristics, could be designed and built at the present time for a rating of 200,000 kw. at 90 per cent power factor, or 222,222 kv-a.

Another interesting feature of this generator is the taking the other winding out of service and the bus tie through the generator will result in synchronism of the two bus sections during disturbances, since the two windings must necessarily be in synchronism, although the effective reactance between buses still exists.

Generator speeds seem to be standardized at 1800 and 1500 r.p.m. for large units, although 3600-r.p.m. machines have undergone a considerable increase in capacity during the year. At Deepwater Station, for instance, 3600-r.p.m. generators of 15,626 kv-a. are installed and at Holland an 13,850-kv-a. unit of this size is used. For the smaller size, 60-cycle generators used

[1] "Design Features That Make Large Turbine Generators Possible"—before A. I. E. E. Pacific Coast Convention, Sept. 3-6, 1929.

in industrial plants, the 3600-r.p.m. machine is the rule. Of interest in connection with high speeds is the 3000-r.p.m., 31,250-kv-a., 33,000-v. generator installed at the Brimsdown station of the North Metropolitan Electric Power Supply Co. in England. This, it is believed represents the highest capacity developed so far at speeds over 1800 r.p.m.

High Voltage Generators Being Considered

Higher generator voltages than those commonly used are receiving considerable attention and at least one station went into service this year with generators of 22,000 v. This was the State Line Station. This use of 22,000-v. generators, however, is not new for previous to the installation of the State Line Machines, 22,000-v. generators were installed at the Powerton Station of the Super-Power Co. of Illinois.

This tendency toward the use of higher generator voltage is a logical one and one that should result in considerable savings in the future. The 33,000-v. generator installed in England has already been referred to. A generator of this voltage is capable of supplying a transmission system without the intervention of step-up transformers; thus not only is their cost saved and that of their housing but also the capitalized value of their losses. From the total savings so effected must be deducted, of course, the additional cost of the high voltage generators. The savings represented in the use of 33,000-v. generators over the ordinary 11,000 to 13,000-v. units lies not only in the elimination of the necessity for transformers but also in the increased cost of other items, such as cable, switchgear and buildings.

Excitation and Voltage Regulation

Practice in regard to excitation voltages and in various stations seems to be pretty definitely standardized at 250 v. The voltage has been adopted almost universally because of economy of copper and switch facilities and the fact that reliability is readily obtainable with 250-v. machines operating at the main generator speeds. The shaft type of exciter is used in practically all cases, with some provision for emergency excitation from another source in case the main units fail.

In the case of Deepwater and Ohio River Stations, it will be noted, sub-exciters are provided. This is a relatively new practice and consists in exciting the main exciter by a pilot or sub-exciter mounted on the shaft of the main exciter. The advantage of this arrangement is that it gives a stable exciter voltage over a broad range, making it unnecessary to provide generator field rheostats.

While it is not wise to draw definite conclusions from the rather selected group of stations covered in this analysis, it seems that automatic control of voltage is preferred to manual control. Where a station delivers current direct into a number of feeders as in the case of a large city station, automatic control of voltage is not as important as it is in a station sending out all its power over one or two long transmission lines, since in the former case, each feeder is usually provided with a voltage regulator which maintains constant voltage at the load even under wide fluctuations of generator voltage. Where the generator voltage is to be maintained during a system disturbance, it is becoming common practice to install automatically operated quick response equipment. The individual exciter makes the high speed excitation problem simpler, as a central excitation system with machines of different size and characteristics could not be regulated satisfactorily even though all generators might be feeding a common bus at the time of a disturbance. With the individual exciter, the main generator voltage can be controlled readily by varying the main exciter rheostat or by a pilot exciter. Thus the main field rheostat may be omitted entirely and by the use of special relays and reversed windings on the exciters, a wide range of excitation may be obtained.

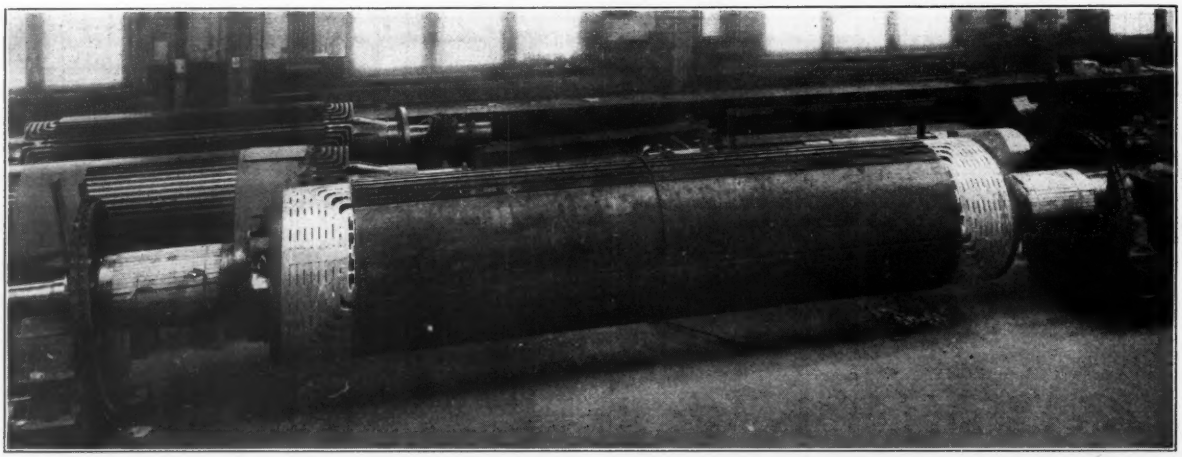


FIG. 3. WOUND REVOLVING FIELD OF THE 160,000-KW. UNIT WITHOUT RETAINING RINGS (PHOTO, COURTESY GENERAL ELECTRIC CO.)

Ventilation and Cooling

As will be noted, the closed system of ventilation with the fin tube cooler is used on all generators in the central stations and in many of the industrial plants. The advantage of the closed system are so numerous that this is not surprising.

While no installation using hydrogen as a cooling medium in generators has been made, experiments in this direction seem to indicate that this will soon be a feature of the larger generators to be placed in service.

Developments in Electric System Practice

ELIMINATION OF INDOOR BUS LAYOUTS AND SWITCHING, IRON CLAD BUSES AND SWITCHGEAR, SYNCHRONIZED AT LOAD SYSTEM AND DEION BREAKER, FEATURES OF THE YEAR'S DEVELOPMENTS

PRACTICE, with regard to the arrangement of buses and switch structures in power station design is not as uniform as it was several years ago. Whereas at that time, most stations used some form of indoor bus structure for the main output, today there are almost as many with outdoor layouts as with indoor. The tendency sems to be toward the elimination of all indoor bus

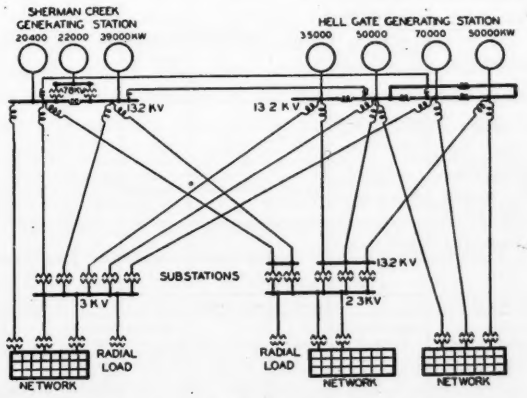


FIG. 1. SYNCHRONIZED AT GENERATING STATION BUSES

layouts. In such instances, the generators feed directly through step-up transformers to high-tension outdoor bus systems.

Where indoor bus systems are used, either the vertical or horizontal isolated place arrangement is used. The selection of which of these systems is used depends largely upon space available and the experience of the designers with either of the two systems. Although it is not evident from the accompanying tabulation, the vertical isolated phase system is perhaps favored more than the horizontal arrangement.

Much more thought seems to be put into the design of the bus and switching system than was the case formerly. Much of the flexibility and reliability of a station depends upon the design of the bus system. For this reason, this part of the system should be given all possible consideration.

As a general rule, the bus and switching arrangements in an industrial power plant is much simpler than that in a central station, although the arrangements are more varied. Of those industrial plants included in this survey, the bus layouts require little comment. Since the power and voltages used are relatively low, the group phase arrangement is commonly used.

Of the central stations using an arrangement in which the generators feed directly to outdoor transformers, Deepwater is typical. Here, as will be noted, the generators connect directly to 11/66-kw. transformers, located just outside the turbine room and these in turn supply the high tension bus system. While the two generators, constituting one unit, that is the high and low pressure shaft generators, are connected, and synchronized on the low tension side of the step up transformers, the individual units can be synchronized only on the high tension side. A similar arrangement is used at the Holland station.

At Delray station No. 3, the bus arrangement differs from all others included in the survey in that auto-transformers are used in place of two-winding transformers. Where the potential change is not great, auto-transformers may be employed to advantage because of their lower cost.

The most startling departure from customary design is seen in the switching and bus arrangement at State Line Generating station. There the conventional switchhouse and indoor bus arrangement has not only been eliminated but has been replaced by an outdoor arrangement which differs radically from any of its kind. An entirely iron clad equipment is used, the bus being enclosed in oil-filled bronze pipe and the connections in oil-filled bronze junction boxes, each phase being

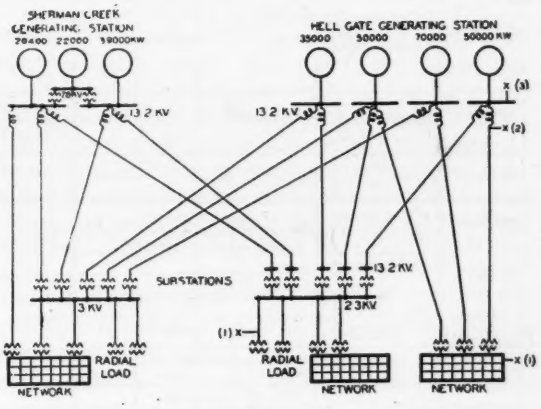


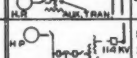
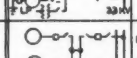
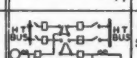
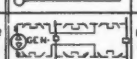
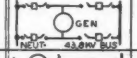
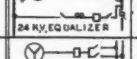
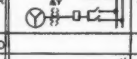
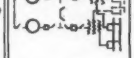
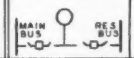
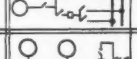
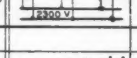
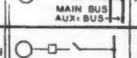
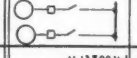
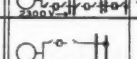
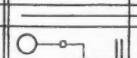
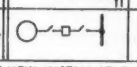
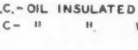
FIG. 2. SYNCHRONIZED AT LOAD

isolated. No open wire circuits are used, all circuits being metal clad.

At this station, a three-section double ring bus is used with one generator connected to each section and metal clad oil-immersed reactors and oil circuit breakers are inserted between sections. All electrical connections are made with single conductor armored cables. Little conduit is used, the conductors being installed in groups in spiral steel pipes.

In general, the various generators are paralleled as near to the machines themselves as possible, either on the low tension side of transformers or on the high tension side. Some sort of "ring" or "star" bus arrangement is usually employed, the individual sections of which are separated by current limiting reactors. Also, where systems are supplied from more than one station it is customary to use either tie lines between stations or to provide an extension of the paralleling bus, or the system is divided into districts tied together by relatively low capacity ties.

ELECTRIC SYSTEM DATA

	NAME OF STATION	BUS AND SWITCHING SYSTEM: SINGLE LINE DIAGRAM GEN. TO BUS	TYPE AND VOLT. OF OIL C.B.	BUS SYSTEM: TYPE.	BUS SYSTEM: VOLTAGE	PROTECTIVE FEATURES: REACTORS	PROTECTIVE FEATURES: RELAYS	PROTECTIVE FEATURES: GROUND	TRANSFORMERS: TYPE	TRANSFORMERS: PURPOSE	TRANSFORMERS: CAPACITY	TRANSFORMERS: WINDING CONNECTION	TRANSFORMERS: POTENTIAL CHANGE
CENTRAL STATIONS	DEEPWATER		7.3 KV. OUTDOOR SOLENOID OPER.	NO GEN. BUS	11 KV.	NONE	GEN. DIFF. RELAYS TRANS. " " GEN. NEUTRAL OVER-CURRENT RELAY OERALL DIFF. RELAYS	NEUTRAL GRND. 2 OHM RESISTOR DISCONNECTS SWITCH NORM. CLOSED	OISC OI, FORCD AIR C.	MAIN PWR. LOCAL PWR.	2 BNKS OF 3-22,500 KV-A EACH 1 OF 3-7500 KV-A EACH	Δ-Y GRND NEUTR'L Δ-Δ	11/66/132 KV. 11/66 KV.
	HOLLAND		15 K.V OUTDOOR SOLENOID OPER.	MICARTA COVERED TUBING	13.8 KV.	NONE	GENERATOR & TRANS. DIFFERENTIAL PROTECTION	NEUTRAL BRK ON L.P. MACHINE	OIWC	MAIN PWR.	3 20 000 KV-A. 3 WINDING 1 Ø	Δ-Y GROUND NEUTRL ON 114 KV	13.2/33/66-114 KV.
	STATION A		15 KW INDOOR MOTOR OPERAT'D	DOUBLE BUS	12 KW.	6.6% IN GEN. LEADS	GEN. DIFF. RELAYS	NETRAL SOLIDLY GROUNDED	—				—
	HELL GATE '29 '30		15 KV 5000 AMPS SOLENOID OPER.	HORIZ. ISOLAT'D PHASE	13.8KV	5% IN GEN. LEADS OF EACH UNIT	GEN. DIFFERENTIAL	NEUTRAL OF E.P. UNIT SOLIDLY GROUNDED THRO O.C.B.	†	†	†	†	†
	EAST RIVER ADD		15 KV 5000 AMPS SOLENOID OPER	VERTICAL ISOLATED PHASE	11.4 KV.	5% IN GEN. LEADS OF EACH UNIT	GEN. DIFFERENTIAL	SYSTEM GRND THRO. TRANS. & RESISTORS	†	†	†	†	†
	STATE LINE		2.2 K.V 3000 AMP 2,000,000 KVA CR.	OUTDOOR METAL ENCL'SD	22 KV.	OIL IMMERSED 9.2% DROP IN SERIES WITH 90000 KVA 3Ø 22 KV. CIRCUIT	GEN. DIFFERENTIAL	NEUTRAL GROUNDED THR C.L.G. REACTOR	7 OIWC 10 " 4 " 2 "	MAIN POWR " " AUX.	20000 KVA " " 10000 " 9000 "		132/22 KV 66/22 " 33/22 " 22/2.3 "
	CAHOKIA		13800 V. MOT. OPR	VERTICAL ISOLATED PHASE	13.8 KV.	3% GEN. REACTANCE	GEN-DIFF. RELAYS	CURRENT LIMIT. RESISTOR IN NEUTRAL	†	†	†	†	†
	DELRAY #3		35 KV MOTOR OPERATED INDOR	METAL CLAD	24 KV.	10% IN EQU'ZR LEADS	GEN. DIFFERENTIAL RELAYS " " NEUT. TO BUS GRND FAULT RELAYS	GEN. NEUTRAL SOLIDLY GRND	OIWC	MAIN PWR.	1 25000 KVA	AUTO TRANS Y	12.5/24 KV.
	OHIO RIVER		25 KV OUTDOOR SOLENOID OPER.	HORIZ. GROUP PHASE	12.5 KV.	NONE	GEN DIFFERENTIAL TRANS "	NEUT. SOLIDLY GROUNDED	FEEDS DISTRIBUTION SYS. AT GEN. VOLTAGE				
	GORGAS ADD					NONE	GEN DIFFERENTIAL		OIWC	MAIN PWR.			13.8/44/110 KV.
	RIVERBEND		15 KV & 100 KV OUTDOOR SOLENOID OPER.	HORIZ 4" TUBING	13.8 KV.	NONE	DIFFERENTIAL BAL. OVERLOAD ETC.	NEUT. GRND'D SOLIDLY	OIWC	MAIN PWR.	2 BANKS 3 EACH 22 916 KVA	3 WNDG 13.8 KV. Δ TO 100 KV TO 154 KV EA. Y GRNDED NEUT.	13.5/100/154 KV
	ENGLISH ADD		15 KV. INDOOR MOTOR OPER		13.8 KV.	6% IN FDRS. 10% BETWEN BUS SECTION	GENERATOR DIFF. " NEUTRAL STA. PWR. TRANS. DIFF RELAY	GEN NEUTRAL GRND. THRO. A REACTOR 3 OHM REACT.	OISC	STA. PWR.	3 1000 KVA 2.75 KV.A. FOR LGHT.	Y-Δ	13.8/44 KV. 66/2.3/11.5 KV.
	FREMONT		15 KV. INDOOR SOLENOID OPER.		2.3 KV.		INVERSE TIME LIMIT RELAYS						
INDUSTRIAL STATIONS	WAUKEGAN N.S.G. & C.CO		7.5 KV INDOOR REMOTE MANU. OPERATED	HORIZ GROUP PHASE	2.3 KV.	NONE	GEN DIRECTIONAL OVER CURRENT RELAYS	NONE	POWER	DISTRIB.	AT GEN.	VOLTAGE	
	ST. PAUL'S												
	VISCOSE		INDOOR TRUCK TY.	DBL BUS GRP. PHSE	6.6 KV.	NONE	REVERSE CURRENT REV. TIME RELAYS	NEUTRAL GROUNDED	OISC	STA. AUX. & SUBSTATION	2-3000 KVA 2-1000 " 2-300 " 8-20 "	Δ Y	66/4.6 KV. 2.3/.04 "
	NEW HAVEN		7500 V SOLENOID OPER. 3Ø	GROUP PHASE	.46 KV.	NONE	NONE ON GENERATOR	SYSTEM IS NOT GRN'D	OISC	FOR LGHTNG ONLY	60 KW.		.44/22/11 KV.
	HARRIMAN		600 V SOLENOID OPERATED	GROUP PHASE	.55 KV	NONE	GEN. DIFF. RELAYS		PWR. DISTRIBUTED		AT GENERATOR VOLTAGE		
	CROCKER BURBANK		15 KV OUTDOOR SOLENOID OPER.	DOUBLE GRP. BUS	2.3 KV.	NONE			OISC	TIE WITH OUT. TRANS	3 1000 KVA	Δ-Δ	2.3/13.5 KV.
	AMERICAN BEMBERG		440 V. SOLENOID OPERATED	GROUP	.44 KV		OVERLOAD RELAYS ON MAIN 'GEN'S.	GRND. CURRNT RELAYS	OISC	PWR. TO FILTR PLANT & INTERCONEC WITH NEAR-BY PLANT	3-1000 KVA	Δ-Δ	.44 / 2.3 KV.
	CHAMPION INTERN	—	—	—	—	—	FUTURE	—	—	—	—	—	—
	MIAMI COPPER CO.		15 KV. INDOOR SOLENOID OPER.	HORIZ. GROUP Ø	6.6 KV.	NONE	GEN. DIFFERENTIAL RELAYS	NEUTRAL GRN. THRO. RESIST.	OISG	STA. AUX.	1 BNK OF 5 TRANS. 780 KW	Δ-Δ	6.6 / 0.44 KV
	AMERICAN GLANZSTOFF		7.5 KV INDOOR MOT. OPERATED	HORIZ.	2.3 KV.	NONE	GEN. DIFF. RELAYS	NEUT. GROUN.	OIAC	MAIN PWR. LIGHTS	1 BNK OF 3 1000 KVA. 1 BNK OF 3 225 KVA	Δ-Y GR. NEUT Δ-Y GR. NEUT	2.3/.44 KV.

† NO NEW INSTALLATIONS * 20,200 KV-A. 12,700 V. 1568 AMP. 8 OHM RESISTANCE, CURRENT LIMITING GROUND REACTORS.
OI.S.C. - OIL INSULATED SELF COOLED
OI.W.C - " " WATER "

An extremely interesting departure from this conventional practice is had in the development by the New York Edison Co. of what they have termed the "Synchronized at Load" system. This arrangement provides a redistribution of reactance in a system so that the reactance between machines and in series with faults is increased considerably.

To illustrate the principle of this system, in Fig. 1 is shown a diagram of connections which has been used in the 60 cycle parts of the generating stations of the New York Edison Co. In Fig. 2 is shown a diagram of the same equipment but synchronized at the load. In the first diagram, it will be noted, the generating buses are tied together very closely, inside the stations by bus tie reactors and outside of the stations by cables at generator voltage. The stations themselves are directly tied together by high voltage cables. In Fig. 2 the direct ties between the generators in the stations have

been removed as have also those between the stations. It is obvious that in this latter arrangement the reactance between generating units has been increased considerably. The arrangement not only increases the reliability of generating sources but also results in lower interrupting duties on circuit breakers and reduction in service voltage disturbances.

The Deion Breaker

One of the notable achievements of the year was the announcement in a series of papers before the American Institute of Electrical Engineers, of the Deion circuit breaker. This breaker incorporates an entirely new idea in circuit breaker design, utilizing the deionizing effect of a thin layer of gas immediately adjacent to the cathode. This breaker was developed as a result of extensive studies made by Dr. Slepian of the Westinghouse Electric and Manufacturing Co., of arc phenomena. In investigating the rate of recovery of the dielectric strength of the space carrying a short a.c. arc immediately after arc extinction, it was found that the ability to withstand the first few hundred volts was recovered almost instantly but that later increments of dielectric strength were recovered at a much slower rate. This pointed to the fact that the first 250 v. were borne almost entirely by a thin layer of gas immediately adjacent to the cathode. Electrons readily replace this layer but others to replace them cannot enter from the metal.

From this, it was evident that it is the slow rate of recombination of the ions in the arc space away from the electrodes that limits the applicability of the arc in air for interrupting high voltages. A fairly obvious suggestion was to reduce, as far as possible, the arc space remote from the cathode and, as far as possible, cause all the arc to play in a space close to the cathode; in other words, to use a large number of short arcs in series. This is what was done in the Deion breaker.

While it is too early to report on the practical applications of the Deion breaker, the preliminary tests made over a period of a year on the Commonwealth Edison Co. system indicate remarkable success. Short-circuit currents as high as 17,000 amp. r.m.s. at 13,200 v. and 28,000 amp. r.m.s. at 6600 v. were interrupted successfully. The tests of these units which were the first of a type indicate ultimate results from the deionizing type of circuit breaker not possible with types having a less scientific principle of arc disposal. Although at present the use of the Deion breaker is confined to relatively low voltages, it is hoped that later it will be found possible to adopt it for use on higher voltages.

Protective Features

The use of current limiting reactors in generator leads and between bus sections is increasing, due no doubt to the higher capacity of the generators and the consequent increased duty imposed on the switching equipment during short circuit. As may be noted from the accompanying tabulation, all central stations paralleling the generating units at generator voltage utilize reactors of some sort either in the generator leads or between bus sections. Of particular interest is the installation of oil immersed reactors at State Line Station. This type of reactor has increased the field of application of current limiting reactors since it can be designed for higher voltages than the dry type and is particularly adaptable for outdoor service. In one instance, reactors of this type were built for a 120-kv. circuit. These units were provided for sectionalizing a 120-kv. 60-cycle bus of a generating station having a capacity of 375,000 kv-a. Each reactor is rated at 2800 kv-a. and introduces 10 per cent reactance at 75,000 kv-a.

Little use is made of reactors in industrial plant installations because of the relatively small amount of power inherent in such system. In these cases, usually, the inherent reactance of the generators themselves is sufficient to limit the short circuit current.

The use of differential relays for the protection of generators is practically universal as may be noted. With the exception of one or two industrial power plants, all stations included in this survey employ this method of protection. Differential current protection is simple and effective under most conditions of trouble. With this scheme of protection, the generator is disconnected from the line only in case of internal failure. It is not common practice to provide relays for disconnecting the generator in case of over current or excessive temperature.

This method of protection is also used on transformers. In this application, the principle is the same as when applied to generators, but conditions of sudden load changes, heavy over currents, tap changing, etc., usually make the solution of the problem more difficult.

Although there have been no radical changes made in relay practice during the past year, some new schemes have been introduced. Of interest is a new scheme of protecting load ratio control units, using a restrained over current relay. One winding is connected to the exciting winding of the load ratio control unit. The other winding is connected to the line. The effect is to change the setting of the relay so that a percentage tripping characteristic is obtained.

Transformer Developments

Although there have been no startling changes in transformer design during the past year, the size of units has steadily increased and the efficiencies still further improved. Efficiencies have been obtained as high as 99.71 per cent at three-quarters load in a 45,833-kv-a. output, 60-cycle, single phase, self cooled autotransformer having a voltage ratio of 15,940 to 7970 and 99.54 per cent at half load in a 40,000-kv-a., 3-phase, 60-cycle, self-cooled, two winding transformer having a ratio of 29,000/13,800.

Load ratio control for transformers has increased during the year and the dimensions of the control equipment have been reduced so that it may now be secured on the side of transformer tanks.

In dissipating the heat losses, forced air ventilation, supplementing self-cooling has been used in a number of installations. This is particularly effective in large self-cooled units in decreasing the radiator surface required for maximum ratings while still permitting operation of the self-cooled unit without the blower losses at moderate ratings. Two types of equipment are furnished, one of which consists of a single blower piped to all the radiators of a transformer, and the other of small individual blowers and housings that are added, one to each radiator.

An Historical Review of Progress in

Switchboard Design and Construction

A Review of Switchboard Developments from the Earliest Designs to Those of the Present Day.

by EMIL G. BERN

SWITCHGEAR DEPARTMENT, GENERAL ELECTRIC CO.

IF IT WERE possible to arrange all the switchboards built in this country since the early days of incandescent lighting, in a single row, the panorama would present an interesting study. It would extend perhaps, about 90 miles. For some distance, we should find not only live apparatus on the front of the board but even buses and connections. Farther on, we should find back-of-board buses but live apparatus even up to 2300 v. on the front. Instrument transformers were available but the safety feature was not yet recognized because the operation of the equipment was still in the hands of operators with technical training.

In another step along the boards, we should find the alternating-current connections and apparatus removed some distance back of the board with their manual operating mechanisms on the switchboard. This meant switchboards of great length. About this period, the so-called embellished switchboard came into being.

Thus far it had been the practice to carry all the main connections to the switchboard structure. This was costly and finally resulted in the electrically operated or remote controlled switchboard. Electrically controlled, the switching equipment was separated from the switchboard, making possible a reduction in the size of the switchboard.

To obtain the maximum display surface in a given space, the benchboard came into existence and perhaps into a too general use. In addition to the increased display surface within range of vision, a benchboard also gives a better perspective view of the whole instrument equipment.

At the period following the financial depression of 1907, there were several large power projects of 60,000 to 110,000 v. and in practically every case benchboards were used. Switching equipments for generator voltages (usually 11,000 v.) were almost invariably installed in masonry compartments. Soapstone came into use early, before the days of concrete, as an excellent material for shelves and barriers subject to the action of electric arcs.

Looking back on those days, we see the formation of two schools in switching equipment design. One advocated multiplicity of connections, instruments and switching devices for any imaginable combination of circumstances, and with a maze of interlocks to prevent doing anything but the permissible, and the other preferred just the necessary equipment and a severe simplicity of connections.

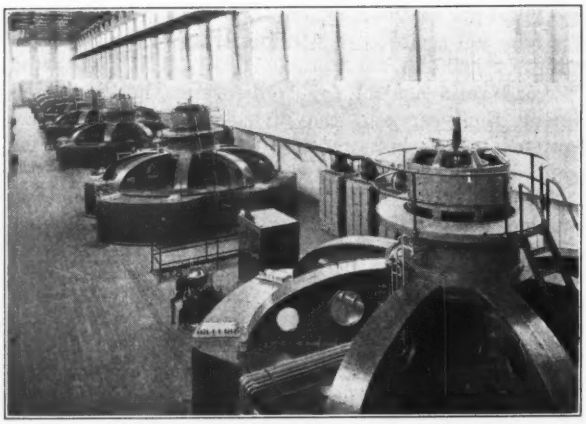


FIG. 1. AUTOMATIC HYDROELECTRIC STATION OF 100,000 KW. WITH AUTOMATIC CONTROL

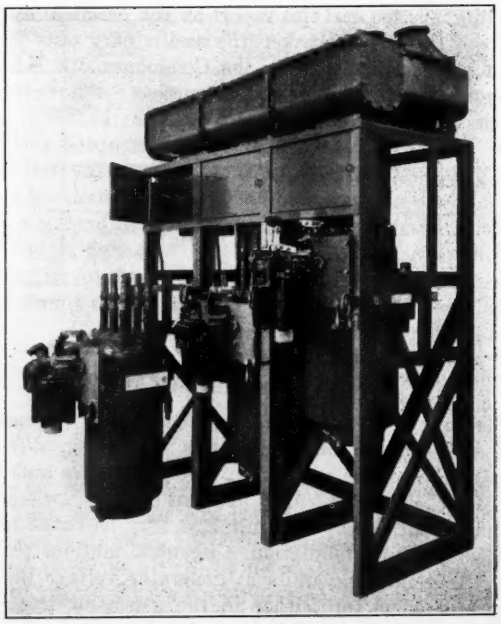


FIG. 2. INDOOR METAL CLAD SWITCHGEAR FOR 15,000-V. SERVICE WITH OIL-FILLED CHAMBERS FOR BUSES AND INSTRUMENT TRANSFORMERS

A visit to some of these installations after a dozen years or more of service is interesting. The simplest equipments have in general given the best service, even under the most severe emergency conditions.

Outdoor Installations

The outdoor switching station came a few years before the World War. One of the first installations was the 70,000/110,000-v. Method substation near Raleigh, N. C. Outdoor switching apparatus, however, was not yet developed, and slightly modified indoor apparatus had to be used. With astonishing speed, this idea spread to all classes of service. Within but a few years, an indoor installation above 15,000 v. was an exception. The war, with its demand for the utmost simplicity, may have been in a measure responsible for the short transition period.

Perhaps agitated by the same emergency, as well as by a natural tendency to extend electric service more universally to rural communities, farms, and temporary construction work, the outdoor switch house was introduced. This came about simultaneously with the development of outdoor fuses and disconnecting switches for switching stations.

One of the outstanding novelties in switchboard design from the pre-war period is the electric control equipment of the Panama Canal locks. This equipment consists of indicating devices for water levels, gates, fender drains, etc., and mechanically interlocked control devices for this apparatus. This embodied probably the first application of the selsyn principle to position indicators, and it has since found an extensive field.

The Safety Feature

The war forced a simplification in construction on one hand and, on the other, a demand for fool proof and safe equipment that could be handled by a less experienced personnel. The dead front switchboard was intended to safeguard the operator; however, maintenance work was also to be considered and the safety feature here became more complex as the requirement for continuity of service grew in importance. The truck type switching equipment, originating in Europe, was developed for American conditions. For heavier service the same principle is applied to motor-operated oil circuit breakers. In this case the oil circuit breaker with its steel cell is made into a truck which also carries necessary disconnecting devices for engaging with the buses and connections.

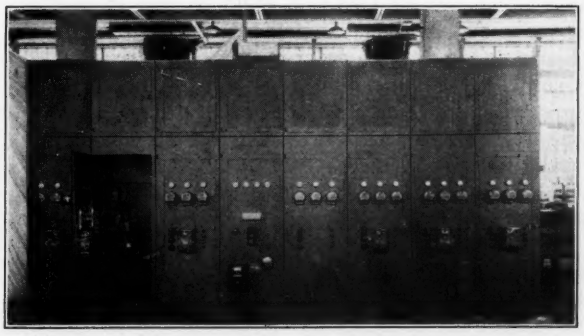


FIG. 3. SWITCHING CUBICLE WITH BUSES, DISCONNECTING SWITCHES, AND INSTRUMENTS FOR 15,000-V. SERVICE

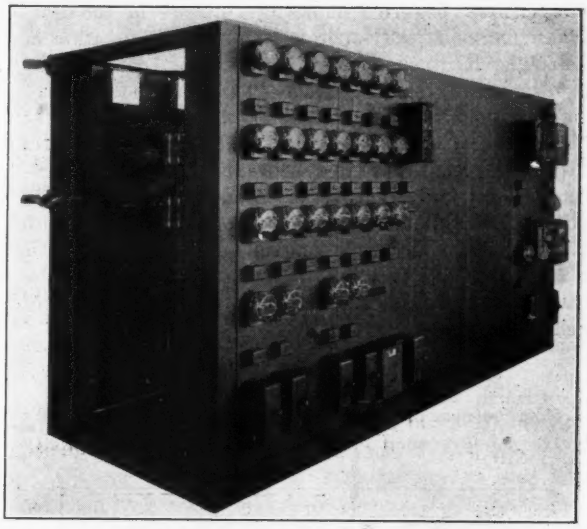


FIG. 6. METAL SWITCHBOARD WITH PASSAGEWAY BETWEEN FRONT AND REAR PANELS

This construction and the older design of similar masonry compartments have been used quite generally for large capacity stations. With the concentration of greater amounts of power, however, it was felt that a better factor of safety against shorts and grounds might be obtained if all the conductors, buses, and switching apparatus belonging to each phase were located in a room separate from the rest of the system. Several of the large power plants built during the last few years are using this "isolated phase construction."

Automatic Switchboards

Automatic switching equipment, which found its first application for railway substation work about the war period, has rapidly broadened its field during the last eight years and now controls all power apparatus. Even for large hydroelectric stations, it is generally admitted that mechanical vigilance is more reliable than human under all conditions—in particular during

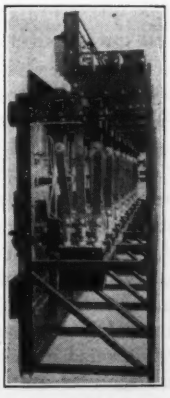


FIG. 4. 76-IN. A.C. FACTORY BUILT COMPLETE SWITCHBOARD FOR 4500/2300-V. SERVICE

FIG. 5. 90-IN. METAL PANELS ASSEMBLED WITH PANEL OF INSULATION MATERIAL

emergencies. Figure 1 shows the interior of the 100,000-kw., automatically-operated hydroelectric station at Louisville, Kentucky. Here each unit is controlled by its own nearby metal cubicle. This automatic, metal- and glass-enclosed cubicle knows how to take care of the hydraulic and other mechanical and electrical features of the equipment, how to synchronize, and how to protect the unit under various emergencies. A single conduit 1¼ in. in diameter connects this control stand with an automatic supervisory control desk near the middle of the room. At this desk is an operator who decides which unit is to act, and who observes the behavior of each power unit.

Metal Clad Switching Equipments

Compactness of construction, a high degree of safety due to a heavy shell of grounded steel, and simplicity

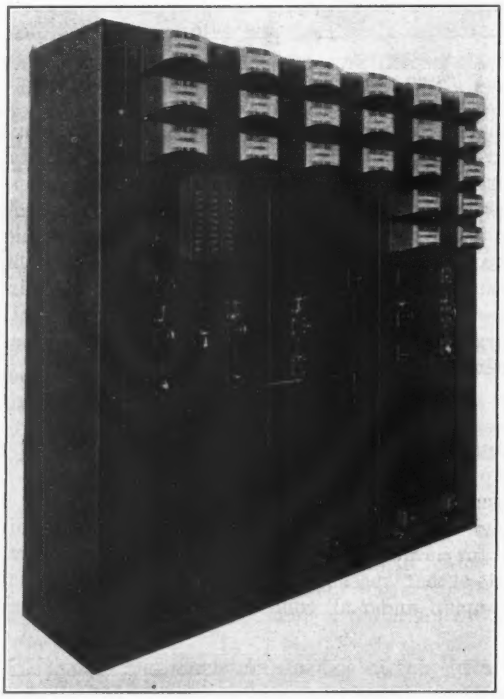


FIG. 7. FRONT SIDE OF METAL SWITCHBOARD, FACTORY BUILT COMPLETE
On rear side are hinged panels for maintenance equipment thorugh which access is had to the wiring and interior details.

of installation as a factory-built-complete equipment, are the features which have recently prompted the introduction of the so-called metal clad switching equipment. This, like the truck type switchboard, is of European descent. It has been used abroad for some time, with buses and instrument transformers immersed in a fluid or semi insulation.

While similar to the truck equipment in several ways, compactness has been stressed more than in any other design, as will be seen from Fig. 2 which is an American-designed equipment for 15,000-v. service, with buses and instrument transformers under oil as an insulating medium. In this figure the right-hand unit is shown elevated to the connected, or operating position. The middle unit is lowered to a position where the breaker is disconnected from the buses and the cables. The left-hand unit is shown taken out of the structure.

A somewhat simpler form of metal-enclosed equipment is the switching cubic shown in Fig. 3 which is manufactured in ratings up to 15,000 v. The metal door serves as a panel for the instrument and control equipment. Disconnecting switches of the conventional type are used in place of the types designed for trucks and elevating equipments. The buses are in the superstructure, and the oil circuit breakers are accessible through rear doors.

Even for small and simple industrial plants, the factory-built-complete construction has become very popular during the last few years. Figure 4 shows a 76-in. switchboard of this type for 4500/2300-v. service. Only the buses are dismantled for shipment and one or more units are crated together. In this manner the time and cost of the installation work are minimized.

Metal Switchboards

Owing to the unmistakable trend in switchboard design towards factory-built-complete features, short time of installation, safety construction, compactness and simplicity of making changes or extensions, metal is the switchboard material of today; however, where insulation panels are required, synthetic materials of proper resiliency have their proper and well defined place.

These trends, as well as their possibilities, are of recent origin. At first there was no apparent need for the dead-front switchboard; electric equipment was usually handled by skilled personnel. The safety feature was not considered. There was no recognized advantage in building an equipment complete at the factory; the user was satisfied to do a large part of the work in the field, and the time allowed for the installation work seemed sufficient for it.

Manufacturing methods, materials, and designs for this class of work were yet in their infancy; hence the switchboard builder had nothing new of value to offer an already satisfied customer. The makers of automobiles and metal furniture deserve credit for the availability of proper steel plate. Last but not least, the recent radical development in lacquers and finishes is also to be recognized as a necessary contribution to the art of modern switchboard manufacture.

When introducing something new, a transition period usually has to be considered and provided for. The manufacturer cannot expect his customer to bubble over with enthusiasm for a new construction to the extent of scrapping his present equipment at the first necessity for extension. For this reason, a metal panel construction was adopted that could be used in extending present conventional switchboards of slate or ebony asbestos. (Fig. 5.) In order to fit a structure designed to support heavy hand-operated apparatus, the pipe-supported metal board was developed. This was also done to meet the demand by some of the most successful installation men for a separate structure that could be plumbed and lined up before setting up the completely equipped panels.

Where the switchboard contains no heavy equipment that need be supported from the frame structure, the pipe supports are usually omitted. The arrangement of wiring in trough-shaped recesses at the sides of the panel remains the same under either condition, and the board is braced to the wall, or is made self-supporting by fastening to the floor.

The insulation of connection studs of instruments, meters, relays and control devices is accomplished in either of two ways. Insulation bushings are provided for each current or potential stud through the panel; or a large hole is punched in the plate for a whole cluster of studs.

In the large power plants, there is usually a clear division of responsibility between the operator and those who look after meters, relays, etc. Hence, it is an advantage in such stations to arrange the switchboards so that the duties of one interfere as little as possible with those of the others. The operator is concerned chiefly with the instrument and control equipment. It is customary therefore, to arrange this equipment on a board separate from the maintenance equipment but,

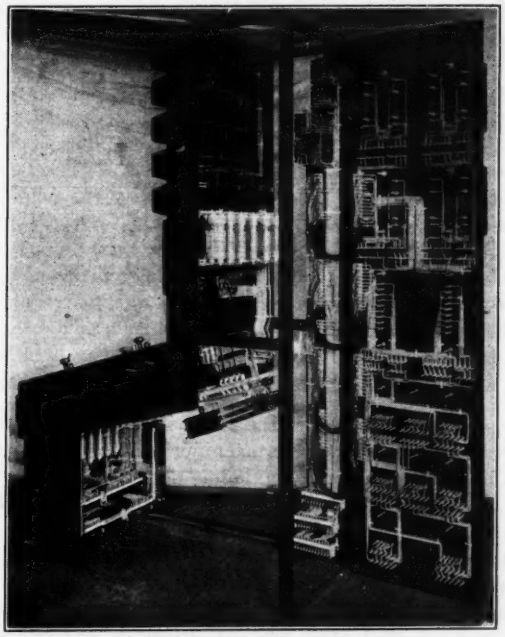


FIG. 8. BENCH BOARD WITH REAR PANEL OPENED TO SHOW METERS, RELAYS AND TESTING EQUIPMENT

for the sake of simplicity, the two should not be separated more than necessary.

With the customary back-to-back arrangement of these boards, a passageway is usually provided between them for access to the wiring; generally with grille enclosure and doors. This construction is readily executed in metal, with front and rear panels joined together, and with the wiring permanently connected.

Hand in hand with the factory-built-complete idea goes the requirement for compactness. Any piece of apparatus built and shipped completely assembled must be limited in weight and bulk to what can be handled with reasonable convenience at the point of installation. As local conditions frequently differ and as simplicity in making changes and extensions is an important requirement, a unit construction is needed for each circuit, or group of circuits. These features have numerous possibilities with a metal construction, all of which help the shipment and installation of complete equipments. Instead of the passageway for access to the connections, the rear equipment may be placed on hinged panels. By opening one of these panels supporting relays, meters, testing equipment, etc., equipment which does not directly concern the operator—the entire switchboard equipment on the circuit is accessible with all its connections, without the need of a working space inside the structure. Compactness obtained by design, without crowding is reflected in lower manufacturing as well as installation costs.

A compact relay, meter, instrument and control board of this type is shown in Fig. 7. This equipment, while assembled on the unit principle so that additional units may be inserted anywhere in the structure. is wired to terminal blocks near the floor and is shipped completely assembled in lengths of units dependent on local conditions at the point of installation.

Figure 8 shows the application of this principle to a conventional form of benchboard, with the maintenance equipment on a hinged panel.

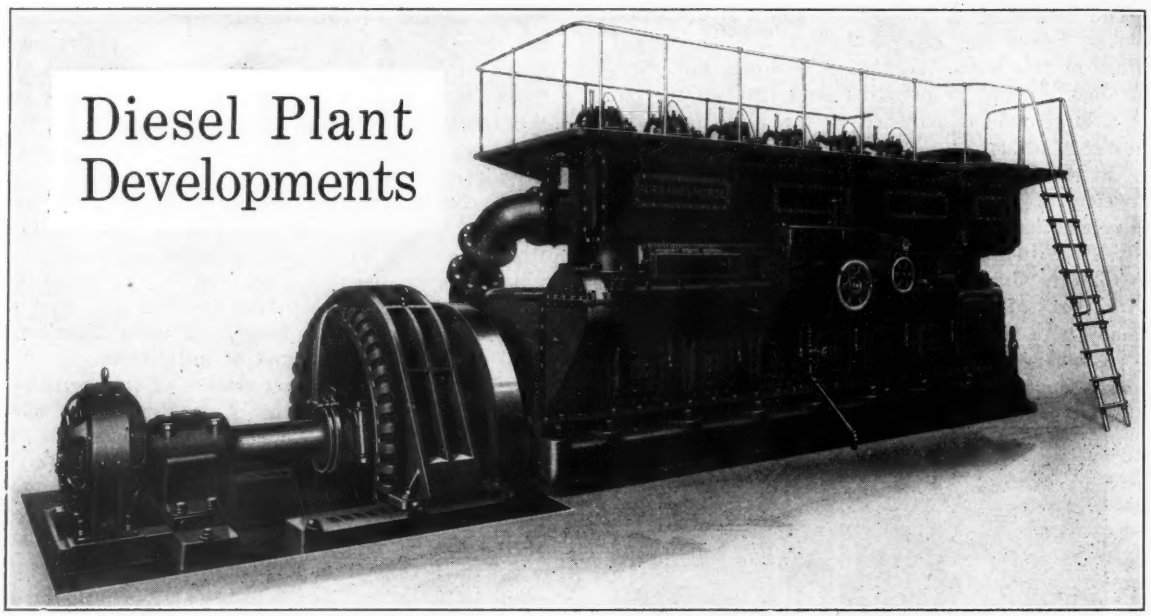
Greater compactness in installation has also been obtained by a better and more compact design of equipment. Here again, the use of metal has helped to shrink the permissible minimum to new limits, all of which makes the task of operating the modern power plant less laborious.

WHEN INSTALLING centrifugal pumps, alinement at the coupling should always be checked even though the pump and motor were received as a unit mounted on a baseplate. Frequently bed plates are sprung during shipment, may be pulled out of place while being grouted in, or as frequently happens, the pump may be forced out of line by poorly laid out piping.

In most cases, a box gage or feelers and a straightedge are sufficient for this check. The motor should be moved until the two halves of the coupling are the same distance apart at all around. The straightedge should then be placed across the two flanges parallel to the shafts. The flanges should agree at the top, bottom, and both sides. If they do not, the motor should be shifted until they are. After this, the shaft should be rotated a quarter of a turn and checked at each point as before.

FOLLOWING TWO MONTHS of unusual industrial activity in July and August, the N. E. L. A. statistical summary of the output of electricity in September shows a small relative decline when allowances are made for the seasonal expansion which should naturally take place at this time. Business during September continued, nevertheless, at a high level. Sales of industrial power for the first nine months of 1929 reached a record total of 34,250,000,000 kw-hr., an increase of 4,120,000,000 kw-hr., or 13½ per cent over the corresponding period of last year.

These increased requirements of energy by the Nation's factories, together with the continuance of unusually dry weather, have placed a heavy demand upon the steam plants of the interconnected systems. In September, the generation of electricity by water power was only 31 per cent of the total output. This is the lowest ratio since the dry weather period of October, 1925, and compares with a ratio of 43 per cent in May, and 38 per cent in September, 1928. During the month, the total hydroelectric production was 12½ per cent below that of August and 12 per cent below that of September, 1928.



Diesel Power Broadens in Scope

HIGH SPEEDS DIVERSIFY APPLICATIONS. COMBINED DIESEL AND STEAM PLANTS SHOW ECONOMY. COMBUSTION EFFICENCY IS IMPROVED. BY R. H. BACON*

IN MANY respects, the year 1929 has been the best for Diesel power since these engines first appeared. This is true, not only because of the broadening out of the field of their use, but also because a definite public consciousness has developed that this type of prime mover has become a factor in the solution of power problems. General interest in the application of the Diesel engine to air craft, to railway locomotives, to power supply for large metropolitan buildings and for use in all types of industrial and marine service has resulted in a growing news value. For this reason, Diesel power has secured front page attention in the public press for the first time in its history. As a result of this growing public consciousness, it has been much easier for the engineer interested in power plant work, to present plans for using such power, when in conference with management executives.

FIELD OF USE GROWS

For Diesel power the field is now extremely broad. Even as broad as it is, however, several trends of application have developed during the year, which are somewhat new and which have made unusual progress. In the railway field, for instance, the Diesel locomotive has been accepted as a definite factor in the solution of the terminal motive power problem. The New York Central placed one order for 35 of these units for use in and around New York City. The Illinois Central Railroad at Chicago with an order for six for terminal service has indicated that there is a definite use for such locomotives with an electrified system. The Chicago & Northwestern Railroad and many others have such units in service.

*Manager, Advertising and Publicity, Fairbanks, Morse & Co., Chicago, Ill.

HIGH SPEED HAS PROVED EFFECTIVE

Somewhat allied is the field of application in connection with excavating machinery. Here the problem is one of getting the maximum power out of the minimum space. The answer has been higher speed Diesel engines, speeds of from 800 to 1200 r.p.m. now being established as entirely practical for such service. Diesel equipped drag line excavators and power shovels have shown up favorably from the economic standpoint as compared with the use of gasoline engine drives. Dredging equipment of the marine type in both suction outfits and with the various types of dipper, clam shell and orange peel buckets is being widely used. Sand and gravel operations with this type of power have shown quite a remarkable development during the year.

Another outgrowth of the high-speed Diesel engine has been in the application of such units to industrial locomotives. Such machines are now available in such sizes as 10, 15 and 20-ton locomotives. No particular problem has been involved in the application of the high-speed Diesel engine to this class of equipment except the necessity for strengthening the chassis and gear trains together with clutches and similar parts. This necessity arises from the sharply increased torque at low speeds as compared with the gasoline engines formerly used, which increase, for a given speed, amounts to as much as 30 per cent.

Another field opened up for the high-speed Diesel is direct connection to driven machines. Many applications of 800 and 1000 r.p.m. engines have been made to centrifugal pumps and through special angle speed increasers to deep well turbine pumps. Again, a new development for the high-speed Diesel engine has been in connection with oil well drilling. In this case it has

been possible to work out a special control which practically duplicates the operation of the old-time steam engine used for such service. This control consists of automatically speeding up the engine following the fall of the tools in the hole and a reduction in speed during the rise.

Use Grows in Power Plants

In the strictly stationary field of application, one of the outstanding trends of the year has been the use of Diesel engines for office buildings, department stores and hotels. During the summer, R. H. Macy & Co. purchased two 1000-hp. engines for the power plant of its department store in New York. These engines operate in conjunction with the steam plant and the combination of steam and Diesel power offers the maximum in plant economy. The new hotel New Yorker in New York City also has a 530-hp. Diesel engine which will operate in conjunction with the steam plant.

Combination of steam and Diesel power offers interesting possibilities for industrial plants as well as for uses such as just cited. Steam demands for process purposes and heating are usually subject to wide variation and it is a simple matter to fit Diesel engines into the load curve in such a way that the utmost in overall economy is secured. Elimination of standby losses for the Diesel, the fact that it occupies little floor space and that it can be started on extremely short notice are important factors in the consideration of the combination plant. The efficiency of the Diesel engine is practically the same in small sizes as for the largest engines and, therefore, even in the case of a small standby unit, high overall efficiency can be attained.

Among industrial organizations, has been a decided change toward the Diesel engine even in metropolitan areas. In the past few years, many industrial plants have gone to purchased power for various reasons. In many such cases, the management felt that it was simpler to buy power and to direct all of the interests of the organization towards the development of the business. After having had an opportunity to compare operating costs with such costs figured on the basis of Diesel power, a decided swing in the other direction is evident. This year, several well-known industrial organizations in the metropolitan areas of New York and Chicago have installed Diesel plants.

In the service of communities, both from privately owned utilities and municipal utilities, there has been a striking increase in the use of Diesel engines. Whether the power system is publicly or privately owned has made comparatively little difference in the acceptance of the Diesel engine. The expansion in both types of service during the year has been the greatest in history.

American Design Has Been Developed

One of the basic reasons for the rapid development of Diesel power has been the remarkable improvement in design of such prime movers by American manufacturers. There was a time when Diesel engine technology was dominated by foreign engineering. That this situation has been entirely reversed is shown by the fact that European builders are now seeking licenses for American engines. Diesel engines manufactured in the United States are now being sold in every country of the world, including Germany where this type of prime mover originated.

In 1929, the trend of engine development has been less in connection with mechanical refinements than in improving the control of combustion. Diesel engines of today are as near mechanically perfect as it is possible to build any type of machinery. Maintenance and repair costs have been reduced to the point where they have practically no effect on the total operating expense. The reliability of the Diesel engine is shown by the fact that it is not at all uncommon for such units to operate 6000 and 8000 hours continuously, without a shutdown even for inspection purposes.

Efficiency of Combustion Improved

During 1929, however, some interesting developments have been made in connection with improved combustion. This has been particularly true in connection with the airless injection type of engine. At one time, it was thought that it was inherently impossible for the airless injection engine to compete with the air injection engine from a fuel consumption standpoint. As a result of much research in connection with the flow of scavenging air through the cylinder and the turbulence of such air, as well as improvements of injection nozzles, it has been possible to secure fuel rates as low as 0.39 lb. per brake horsepower-hour. This compares favorably with the best results obtained with air injection. Airless injection engines are now being offered with definite fuel guarantees of around 0.43 lb. per brake horsepower-hour as compared with a standard of 0.46 and 0.48 lb. a few years ago. The new guarantees are on a conservative basis as compared with the test floor results mentioned.

For the Diesel engine, the combustion problem is somewhat analogous to that encountered in boiler furnace practice. It is a matter of getting each minute particle of fuel in contact with a minute particle of oxygen, in a space of time represented in thousandths of a second, so that combustion will be complete. This has had to be accomplished, of course, without sacrifice in overall performance, since a small saving in fuel cannot be justified, if the overall operating expense is increased.

Fuel Standards Are Being Established

Fuel standardization has also received considerable attention from the manufacturers as well as the users of Diesel engines. The Oil and Gas Power Division of the American Society of Mechanical Engineers, in coöperation with the oil companies and the manufacturers, made definite progress during the year in arriving at fuel standards. The preliminary report made at the A.S.M.E. Oil & Gas Power Division conference at State College in June was well received. This work in coöperation with the American Standards Association is still under way and it is expected that eventually definite specifications for oil fuels for Diesel engines will be available. At present, it would appear that the specifications will be of a rather broad character so that the user will have no difficulty in securing oil which will meet the standards and which can be purchased in any locality at a price that will not increase the operating cost. In time, lower cost of oil fuels for Diesel engines should be reflected as the result of the work on standard specifications.

Recent Diesel Engine Progress

TYPES ADAPTED TO CONDITIONS OF SERVICE. BETTER MATERIALS PERMIT LIGHTER WEIGHT. SOLID INJECTION GAINING. BY HENRY C. LEHN*

INITIAL MARVELOUS PROGRESS of the mechanical arts, which the first quarter of the twentieth century has witnessed, is notably exemplified in the advance of the internal combustion engine. On the one hand is the intensive and highly specialized development of the carbureter engine for its particular field and, on the other, the rapid progress of the Diesel engine into practically every line of power service.

Diesel adaptation to numerous widely differing fields has, as a natural result, prevented standardization of type to the degree occurring in the case of the carburetor engine. Thus, the two and four-cycle and the single and double-acting forms all exist and will continue to do so. These several types are, however, beginning to be rather distinctly marked for particular fields, the development up to the present time indicating a permanent field for each. Concurrently, design of each type is arriving at a certain degree of standardization.

TWO VS. FOUR-CYCLE

Example of the establishment of types is shown in the strong tendency toward two-cycle for larger sizes and four-cycle for smaller units. This demarkation of the two and four-cycle fields is due as much to commercial considerations as to engineering or theoretical factors. The apparent advantage of the two-cycle principle is its smaller cylinder displacements for a given power output and absence of valve gear, which should result in lower cost per horsepower, is incompletely realized in practice in the smaller sizes. With increasing cylinder dimensions, the two-cycle type begins to attain the advantage which, from theoretical considerations, it should possess and, in the larger sizes, shows a decided commercial superiority. The slightly lower fuel consumption of the four-cycle type in all sizes is, in most cases, either of minor importance or outweighed by other considerations.

In marine service, the more uniform torque of the two-cycle type and, with a given number of cylinders, its greater facility in starting and maneuvering are important factors, particularly in the smaller sizes. So far as reliability in operation and general excellence are concerned, there would appear to be little to choose between the best modern design of either type in any size.

SINGLE OR DOUBLE-ACTING

Turning from the question of cycle to that of mechanical design, the double-acting principle should, on the surface, be applicable through a considerable range of size with resulting overall commercial economy but here again the advantages are realized only in engines of cylinder dimensions approaching the maximum now possible. For large engines, however, the double-acting design is proving its adaptability and commercial fitness in both the two-cycle and four-cycle types. In the latter, the inlet and exhaust valves in the bottom cylinder end and their driving mechanism are a problem in design and an item of expense, comparatively greater than in the single-acting type. Reliability and efficiency of these large engines are proved by their increasing use in ships of all sizes. Considering vessels of 8000 t. and above, at the present time there are under construction throughout the world, nearly three times as many motorships as steamers, with units up to 7500 hp. and installed horsepowers as high as 25,000. In the stationary field, engines of this same type are applicable, where large powers are required.

In the medium sized power plant of from 300 to 1500 hp., the single-acting, four-cycle type of moderate rating and weight per horsepower predominates and, at present, is well established in that service. Naturally, accompanying advance of the art, tendency toward higher ratings and lower weights per horsepower has been particularly marked during the past year or two, so that the medium sized stationary engine will undoubtedly progress along these lines.

WEIGHT IS DECREASING

In light weight engines for high speed marine service, engines now appear of from 15 to 20 lb. per horsepower rated from 85 to 90 lb. brake mean effective pressure and running at piston speeds from 1600 to 1800 ft. per min. Here all possible refinements in design and materials are used, including aluminum pistons and, in some cases, aluminum connecting rods to reduce the weight of the reciprocating parts. In these features the design parallels that of the modern carburetor engine.

In this class are engines for Diesel locomotives, in which line considerable progress has been made and, newest on the list, engines for aeroplanes and motor trucks. In the latter, the lower fuel consumption of the Diesel engine and its ability to use cheaper fuels is of first importance in reduction of operating cost. The considerable problems met in the attempt to adapt the Diesel principle to the comparatively small unit required for aeroplanes and automobiles and, at the same time, to produce a commercial engine, have retarded development for these fields but these problems are fast being solved.

SOLID INJECTION ADVANCES

With respect to the method of fuel injection, notable progress is being made in the mechanical system, which is being adapted to all types and sizes. The use of high-pressure spray air is, beyond doubt, the easiest way of obtaining good combustion and high mean effective

*Chief Engineer, Worthington Pump & Machinery Corp., Buffalo, N. Y. Works.

pressures but the increased first cost involved in the compressor, as well as the additional maintenance and care in operation, make its elimination highly desirable; hence the wide spread and intensive investigation of mechanical injection both in laboratory experimentation on the behavior of oil jets in high-pressure air and in the practical application of the system to actual engines.

Originally, the Diesel principle involved the burning of the fuel at a constant pressure practically no higher than the pressure of compression and this condition is easily met with the use of spray air. With mechanical injection, it is difficult to prevent the pressure rising, or if prevented, to obtain good fuel economy; hence the tendency to operate with high pressures, giving increased thermal efficiency but with the disadvantage of requiring heavier construction to withstand the higher stresses. To some extent, this difficulty is overcome by careful selection of the improved materials now available.

As the system requires the measuring and delivering of minute quantities of fuel in minute fractions of a second against pressures up to 5000 lb. per square inch, new problems in pump and spray valve design were encountered, which at first were the source of considerable difficulty, particularly as the high degree of accuracy of workmanship required was not appreciated. Specialized design and manufacture have gone far toward solving these problems and entirely reliable pumps and spray nozzles are now available. As a result, while still far from supplanting the air spray, mechanical injection is beginning to predominate in small and medium sizes and is meeting with a certain degree of success in cylinders of the larger dimensions. Low fuel consumptions are being obtained, sometimes slightly lower than with spray air injection. This good economy is, of course, partly due to the higher mechanical efficiency obtained with the removal of the compressor.

In reviewing recent progress, there is observed, as applying to all types, a steady improvement in combustion, particularly with mechanical injection, making possible higher ratings; the perfecting of mechanical design and the use of higher grade materials resulting in lower costs and weights; finally, the tendency toward development and selection of type for service. The first two items operate directly to improve the overall commercial efficiency and the third has at least an indirect effect in the same direction. Further improvements in combustion may be looked for as the theory of mechanical injection becomes better established and manufacture of the parts involved is standardized.

Future Progress Linked with Better Materials

Also concerned, in its effect on the allowable working pressures and with them the economy, is the question of materials. Forgings and castings of greater strength will result in either lighter weights and costs with present pressures or present weights and costs with higher pressures, ratings and consequent overall efficiency.

Thus the future of all types is, to a considerable extent, dependent upon the progress made in the metallurgical arts, the increasing size of engines and increasing ratings demanding increasingly better materials to withstand the higher mechanical and heat stresses. This demand has had its share as the cause of intensive study of materials resulting in numerous alloy steels of high strength, intricate steel castings of thin section now possible and the recent revival of interest in cast iron, which has already produced encouraging results. The latter, particularly, is of importance to Diesel engine construction in making possible the retention of cast iron with all of its desirable qualities in parts for which present day practice in size and stress is beginning to make it unsuitable.

In the short period of its history, the Diesel engine has made headway in all lines of power service and is becoming a factor of importance in the majority of them. The progress it has made in the past and is making at present and the intensive study being given to all phases of design and construction would seem to assure continued development for some time to come.

Air Heaters and Economizers Improve Boiler Efficiency

In steam power plants, the tendency for the past few years has been toward higher pressures and temperatures as well as toward increased outputs from the different pieces of equipment. In steam boiler units, consisting of a furnace and boiler, both of these tendencies combine to give a high exit gas temperature with corresponding heat losses which tend to offset the thermal and economic gains in the other direction.

For this reason, the recovery of this heat, without going to impossible boiler sizes, has been the subject of much investigation and has resulted in the development of two practical methods, the economizer which transfers heat from the exit gases to the boiler feedwater and the air heater which transfers the heat from the exit gases to the air for combustion. Designers are not agreed which is the better solution for all cases but the present feeling seems to be that the use of the two together gives the most flexible arrangement.

To be most effective, an economizer should receive feedwater fairly cool, somewhere between 210 and 225 deg. F. which is also the most effective range for extraction heaters. With preheaters there is a fairly definite temperature of the air for combustion, around 350 deg. for stokers and 500 deg. for pulverized coal, beyond which it is thought unwise to go at present. This limits the range of the air heater.

By using proportionately smaller elements with the economizer ahead of the air heater, extraction heaters can be used to heat the feedwater temperature over the low temperatures where they are most effective; the economizer can be used to heat the feedwater at the higher temperatures and the air heater can be used to reclaim the heat in the exit gases between the temperature at which they leave the economizer and the dew point, the lowest practical limit. In some stations, an air heater is used and some of the heat in the air transferred to the feedwater. This tempers the air to the furnace and eliminate economizer corrosion.

Impurities carried over with the feedwater may lead to serious troubles in piping, valves, engines and turbines by building up deposits or causing corrosion. Caustic soda widely used for internal boiler treatment will corrode copper alloys.

Trends and Developments in Diesel Practice

LARGER AND SMALLER SIZES EACH HAVE INCREASING FIELDS. SPEEDS INCREASE AND WEIGHTS DECREASE. DIESEL HAS DISTINCT PLACE IN CENTRAL STATION FIELD

DIESEL DEVELOPMENT in this country has so advanced that engines of this type are not only finding a market in European industrial centers but recently, for the first time, a foreign concern secured the Belgium rights to manufacture and sell an American type Diesel engine. Rapidity of growth in the use of Diesel engines in the United States is shown in Fig. 1. To appreciate this increase it is well to reflect upon the fact that the first Diesel central station was built in 1902. The effect of the expiration of the Diesel patents in the United States in 1912 is manifest. Only 19 yr. ago, the first sea going vessel was equipped with Diesel engines. During the past year, more Diesel engines

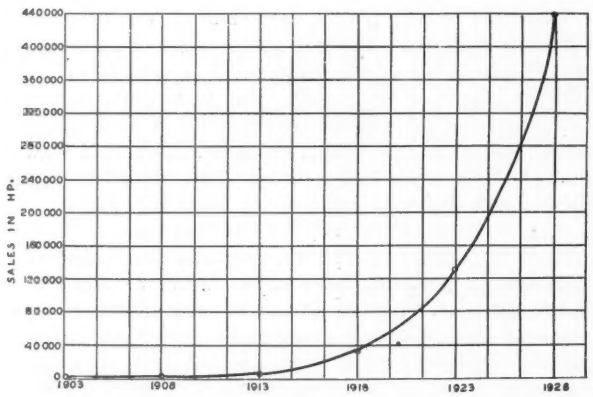


FIG. 1. CURVE SHOWING RAPID GROWTH OF DIESEL INDUSTRY IN THE UNITED STATES

were installed for marine service than were steam engines. Tendency toward larger sized Diesel engines has been accompanied recently by a trend toward manufacture of small size units which have had an increasingly wide application for industrial uses.

MOST RAPID DIESEL INCREASE IN MARINE FIELD

In no other power field has Diesel engine application increased so rapidly in both number of engines installed and in total horse power as in the marine field. At the beginning of 1929, the gross tonnage of motor ships under construction throughout the world was 1,395,868 t., while the gross tonnage of steam ships under construction was only 1,211,553 t. Growth in marine application has been greatly influenced by some inherent advantages held by this type of power, such as ease of loading and feeding fuel, small amount of cargo space required for storage and greater uniformity in quality of fuel as found in the various ports throughout the world. The German battle cruiser Ersatz Preussen, now building, is designed to be driven by Diesel engines totaling 50,000 hp. No less than 20 motorships, with sufficient power and speed to justify the accommodation of passengers, are being commissioned for service between European and California ports.

*Power Plant Engineering, Apr. 15, 1929, page 467.

For railroad service, reliability and low cost of maintenance are just as important factors as light weight and low cost. Although the total number of Diesel locomotives all over the world does not now exceed 70, its superior speed-torque characteristic and its greater availability due to possible 24-hr. service, makes this field a promising one for the Diesel engine. Thus far, heavy weight and high first cost have been effective deterrents to more general use. A 300-hp. 12-cylinder "V" type Diesel engine which has been installed in a Lehigh Valley low-speed switching engine, directly connected to a 195-kw. d.c. generator, is claimed to have a speed-torque characteristic which is better than that of the steam locomotive and to have a fuel cost one-fourth to one-sixth of a steam locomotive.

Thirty-five Diesel locomotives, aggregating more than 10,000 hp., have been built by two manufacturers in this country since Oct. 1, 1927. A number of large railroad systems are investigating Diesel power and making trials. A 500-hp. Diesel, direct connected to a 350-kw. generator, recently went into service on a Scottish railway and a 2660-hp. high-speed Diesel locomotive, developing rated horsepower at 0.43 lb. of fuel oil per br.hp-hr., is now operating on the Canadian National Railway. This locomotive consists of two units weighing 325 t. and has a continuous tractive effort of 42,000 lb. while, during the acceleration period, this effort is 100,000 lb.

DIESEL-ELECTRIC DRIVE HAS SUPERIOR TORQUE

Widespread application is being made of Diesel power to isolated and semi-portable uses. Notable examples of this are in powering dredges and excavators. Heretofore, steam has been the ideal to which excavating machine designers have looked because of the ability of an ungoverned, throttle-controlled unit of this kind to give a uniformly rising torque with decreased speed. Reference to Fig. 2 will show the superior torque of the Diesel engine, especially when arranged as a Diesel-electric drive. Increase in torque at the lower speed is nearly 30 per cent for the same size engine. Also, lower final speed, before stalling, is available with the Diesel drive. This field is therefore a particularly fertile one for the Diesel engine.

Pipe-line and oil-field services continue to be attractive applications. In the latter case, however, there is a more or less long period during which gas goes to waste while oil may be stored for later sale. To serve this particular condition, several manufacturers have brought out engines that are readily convertible from gas to oil burning. Small oil engines geared to air compressors have long been used by contractors on construction work. Since the introduction of the high-speed, light-weight Diesel, the Diesel engine is being applied increasingly to services of this kind.

Because of certain city ordinances prohibiting use of gasoline engines in building basements, high-speed,

small-size Diesel generating units are finding an increasing application in such buildings where cost of purchased power is high. Relatively low initial costs, low head room, small floor space and the self-contained characteristic of such units, as well as the opportunity for heat reclamation from jacket water and exhaust gases, open many possibilities for Diesel power in this field.

Standby Service Important Field for Diesels

Standby and peak load services still remain superior fields for Diesel application due to absence of fuel cost during non-operation periods and to the fact that Diesel engines may be quickly started and loaded to full capacity, hence they are being used increasingly as auxiliaries to other sources. A recent Diesel installation in the large new Hotel New Yorker is an unusual example of this kind of service.

At the present time, Diesel engines cannot compete with steam turbines in central station service for plants over 50,000 kw. in capacity because of higher first cost and B.t.u. consumption per kw-hr.; however, the Diesel engine occupies a definite place in the central station field. It serves as an excellent temporary source of power in isolated and rapidly growing communities until the section has built up sufficiently to warrant building a modern steam station or until connection with high-tension sources is justifiable. Another important sphere of power service which is ably being assumed by Diesel engines is as motive power for municipal and industrial plants which are located in sections where purchasable power is high. Power customers and those desiring electric power are interested alone in the purchase price, if such power is reliable; they are not concerned with the production cost of power.

Standardization Aids Diesel Industry

Marked advance has been made in standardizing not only the general design of the American Diesel, which shows a tendency toward simplification of lines and centralization of control, but also the design of parts. Standardization of Diesel engine parts, brought about by the manufacture of such parts in specialized plants in the same manner that certain automobile parts are manufactured today, is progressing rapidly. In this matter, we had hoped that by this time we should have received much valuable data from the Diesel Engine Society—the society of Diesel manufacturers. If this society can be caused to function with the same efficiency and in a manner similar to the N.E.L.A., the Diesel industry will be greatly benefited and each Diesel member-company will receive its reward in return for its contribution.

Trend Toward Higher Speeds Continues

Rotative speeds of 1000 r.p.m. and piston speeds of 1500 ft. per min. are not unusual in commercial applications. In Table II, we find reported a speed of 1200 r.p.m. and a piston speed of 1800 ft. per min. Experimentally, speeds of 2000 r.p.m. and piston speeds of 2100 ft. per min. are giving great promise for the future. Smaller weight, space and cost accompany weight reduction. One manufacturer advertises V-type marine engines up to 3000 hp. weighing 21 lb. per hp. Engines of the cruiser Ersatz Preussen are reported to weigh only 17½ lb. per shaft horsepower and the Packard aeroplane engine is reported to weigh only 3 lb. per br.hp.

Alloy Metals and Precision Manufacture

Increased speed has been made possible by use of many agencies such as alloy materials, precision manufacture, controlled pressure lubrication and more careful consideration of fuel-injection methods and scavenging. A scavenging method which depends upon the use of individual automatic valve groups, placed directly before each cylinder part, has been developed recently by an eastern shipbuilding concern and the scavenging system developed by W. B. Chapman* which has demonstrated efficient scavenging at high rotative speeds gives promise of wide application.

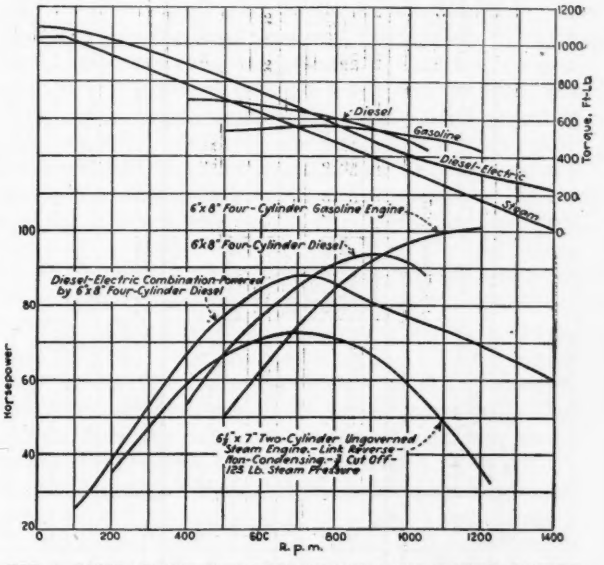


FIG. 2. COMPARATIVE SPEED-TORQUE AND SPEED-POWER CHARACTERISTICS OF DIESEL, GASOLINE, DIESEL-ELECTRIC AND STEAM-DRIVEN EXCAVATING MACHINES

Improved Part Design

Better design of cylinder heads and use of better materials have added much strength to this vital part. Stiffer shafts made of alloy steels and more effectual understanding of critical-speed phenomena have greatly reduced crankshaft failures. Greater attention than formerly is being given to supercharging. The two reasons for supercharging are illustrated in two recent Diesel installations. Supercharging is employed in the engines installed in New York City by R. H. Macy & Co. in order to increase the normal rating of the engines at sea level. At the Moffat Tunnel plant, supercharging is used as a means for restoring sea-level rating at high altitude.

Diesel Engine Efficiency Is Increasing

The 15,000-hp., 9-cylinder, double-acting, two-cycle M.A.M. Diesel installed at the Hamburg Electric Works in Germany has given a thermal efficiency on test of 38.1 per cent without the scavenging blowers. This repre-

*Power Plant Engineering, April 15, 1929, page 467.

DIESEL PLANT DATA

PLANT	LOCATION	KIND OF SERVICE	ANNUAL NET STATION OUTPUT KW-HR	AVER'GE NET STATION OUTPUT KW DAILY	CORRES. DAILY HOUS LOAD KW. (1)	PEAK LOAD KW. YR.	LOAD FACTOR (2) PLANT	LOAD FACTOR (3) MACH.	H.P. OF UNITS	NO. CYLINDERS	CYCLE	FUEL INJECTION	CYLINDER AIR COMPRESS	FUEL BAUME° GRAVITY	FUEL B.T.U. PER GAL	OIL CONSUMP. KW-HR PER GAL FUEL	OIL CONSUMP. KW-HR PER GAL LUBRCT	TYPE OIL PURIFICATION FUEL	TYPE OIL PURIFICATION LUBRICNT	FUEL OIL STORAGE TYPE AND LOCATION	FUEL OIL STORAGE CAP. GAL. EACH UNIT	COOLING WATER METHOD	COOLING WATER TYPE SYSTEM	COOLING WATER TEMP.° IN	COOLING WATER TEMP.° OUT	TOWER BASIN CAP. GAL.	WATER TREAT. TYRE	WATER TREAT. CAP. GAL/DA	AIR FILTER TYPE	AIR FILTER CAP. C.F.M.	EXHAUST TEMP.° (4)	EXHAUST TYPE COOLING	EXHAUST TYPE MUFFLER
CENTRAL STATIONS																																		
NORTHWESTERN P. & L. CO.	SPIRIT LAKE IOWA	L & P	——	4800	15	510	——	——	1-625	6	4	AIR	——	26-28	——	10.15	——	NONE	CENT.	3 ABOVE GRND.	19 900	TOWER	OPEN	65	120	15 000	ZEOLITE	24 000	MULTI-CELL	9000	710	MANIFOLD	SOUND WAVE FILTER
PHELPS DODGE CORP	BISBEE ARIZ.	"	18657 19 (4)	68375	142 (5)	——	——	098	2-1250 2-2200	5 4	2 "	"	PISTON	16-20	147 000	11.4	2175	FILTER	FILTER	2 TANKS ABOVE GROUND	211 000	SPRAY POND	"	70 90	110 30	——	LIME BARIUM	6 000	NONE	——	600 750	WATER	NONE
"	GLOBE ARIZ.	"	8383555 (4)	30 700	23 (5)	——	——	0.48	2-1250	5	2	"	"	"	"	10.0	1828	"	"	TANK ABOVE GROUND	21000	TOWER	"	"	"	——	"	3500	"	——	"	"	"
"	MORENCI ARIZ.	"	17149 831 (4)	62 800	82 (5)	—	—	0.49	6-1250	5	2	"	"	"	"	10.5	2600	"	"	2 TANKS ABOVE GROUND	——	"	"	"	"	——	LIME	4000	"	——	"	"	"
TEXAS LOUISIANA POWER CO.	CLIFTON TEXAS	"	940 458	3800	400	300	0.526	0.53	1-400	4	4	"	"	24-26	143 000	10.80	1086	"	CENTRIF	TANK ABOVE GROUND	12 000	"	"	80	120	50 000	NONE	——	MULTI CELL	——	600	NONE	SOUND WAVE FILTER
"	WHITEWRIGHT TEXAS	"	1 265 600	4300	75	600	0.224	——	3-560	4	2	SOLID	"	"	"	8.65	1270	"	"	2 TANKS ABOVE GROUND	10 000	"	"	"	115	"	"	——	"	——	"	"	TANK
TUCSON G.EL.L & P. CO.	TUCSON ARIZONA	"	17147 128	70000	6000	5000	0.415	0.21	2-500 2-520 2-1000 2-3750	3 4 6 6	4 4 4 4	AIR	"	24 " " 19.5	148 000 " " 147 000	9.8 9.8 10.0 12-13	1921 3052 1800 2285	SETTLING & FILTER	FILTER & CENTRIF	1 STEEL 1 " 1 " 2 " 2 GALV. IRON	250 000 105 000 14000 10 000 EA. 5000	SPRAY POND	"	98	120	"	ZEOLITE	130 000	2 AIR WASHERS (6)	(7)	(8)			
MUNICIPAL PLANTS																																		
MUNICIPAL PLANT	BRADY TEXAS	"	——	——	——	——	——	(9)	1-100 1-300 1-360 1-750	2 3 3 4	2 2 2 4	SOLID " " "	CRANKS " " PISTON	——	——	——	——	FILTER 4 TIMES	FILTER CENTRIF	STEEL TANKS	——	TOWER & COILS	CLOSED	—	—	——	WATER SOFTENIN'	——	——	——	——	——	——	——
"	EMAUS PA	"	——	——	——	——	——	——	1-240	4	4	"	"	28-34	——	——	——	——	FILTER	2 TANKS ABOVE GROUN'	10000	DIRECT FROM C' MAINS	OPEN	—	—	——	——	——	MULTI CELL	——	—	——	SOUND WAVE FILT'R
"	HAWTHORNE N.J.	PUMPING	——	——	——	——	——	——	3-100 1-150	2 3	4 4	" "	"	30-32	——	——	——	——	CENTRIF	"	100 000	"	"	—	90 110	——	——	——	——	——	—	MANIFOLD	"
"	HOBART IND.	L & P	1600 000	——	—	1000	0.35	——	1-380 2-560	6 4	4	"	"	——	——	10	——	SETTLING	"	"	10 000	SPRAY POND	CLOSED	—	—	10 000 O'SHEAD	NONE	——	MULTI CELL	——	—	——	"
"	HUDSON MASS	"	3 000 000	12 000	640	800	0.556	——	2-900 1-675	8 6	4	AIR	"	20	147 000	11.2	2000	"	"	"	20000	HEAT EXCHNG	OPEN	70	130	——	"	NONE	NONE	NONE	750	MANIFOLD	"
"	MENASHA WIS.	PUMPING	——	——	——	——	——	——	1-825 1-600 1-800 1-1200	2 6 6 6	4	"	"	——	——	——	——	——	FILTER CENTRIF.	——	——	——	—	—	——	——	——	AIR MAT	——	—	"	"
"	PRINCETON ILLINOIS	L & P PUMPING	1900 000	5200	3	675	0.32	——	1-600	6	4	"	"	28-30	148 500	10.5	1500	SETTLING	RECLAIM'R	1 TANK ABOVE GROUND	15 200	TOWER	CLOSED	—	115	9 000	——	——	MULTI CELL	——	600	"	TANKS IN SERIES
"	ROCHELLE ILL	"	——	——	——	——	——	——	1-365 1-550 1-900	4 6 6	4 2 4	" " SOLID	" " PUMP PISTON	32-36 26-30	——	——	——	——	——	3 TANKS ABOVE GROUND	3-11500	"	"			2600	——	——	——	——	—	——	TANKS
"	RUSSELL KAN.	L & P	800 000	2800	—	273	—	——	1-100 1-200 1-350	1 2 5	4	"	——	28-30	——	9	——	RECLAIM'R	——	1 TANK UNDER GRND.	15000	"	"	80	110	6000	ZEOLITE	2000	MULTICELL	——	550	MANIFOLD	TANK
INDUSTRIAL APPLICATIONS																																		
CHAMPLIN REFINING CO.	ENID OKLA.	"	4595120	12 041	24,37	752	0,867	0,894	2-560	4	2	SOLID	PISTON	24-26	148 616	10-37	1047	SETTLING SCREENIN'	CENTRIF.	1 TANK ABOVE 2 BELOW GRND	1-12464 2-634.5	TOWER	OPEN	65	100	17 640	CONDENSA.	ADD 125 GAL/DAY	MULTICELL	——	600	MANIFOLD	CONCRETE PIT & PIPE
FRIGORIFICO ARMOUR DE LA PLATA	ARGENTINE SOUTH AMERICA	"	330 000	9160	——	800	0.34	0.24	2-820	8	4	"	——	12	151 000	11	400	CENTRIF.	RECLAIM'R	2 TANKS ABOVE GROUND	——	EXCHNGE	CLOSED	—	—	15 000	——	325	NONE	——	—	——	TANK
FRIGORIFICO ARTIGAS	MONTIVIDEO URAGUAY S.A.	"	1788 000	6000	—	560	0.54	0.52	1-850	8	4	"	——	"	"	12	450	"	"	"	——	"	"	—	—	10 000	——	300	"	——	—	——	"
HOTEL NEW YORKER	N.Y. CITY	"	1750 000	(6)	—	350	——	——	1-535	8	4	"	NONE	24-28	——	7.5	——	——	CENTRIF.	STEEL TANK BELOW FLOOR	6900	CITY WATER	OPEN	—	—	——	——	——	MULTICELL	——	—	EXHAUST WATR. HTR.	PASS-THRO EXH. HTR.
MANGANIFER'S IRON CO	CROSBY MINN.	"	2332 800	6400	26	1042	0.46	0.48	1-440 1-330	4 3	4	"	——	27-30	——	12.01	2148	CENTRIF.	"	2 TANKS	2- 12000	BENT TUBE UNIT	CLOSED	80	105	16 000	ZEOLITE	60000	NONE	——	500	MANIFOLD	TANK
LOUISIANA DELTA FARMS	DELTA FARMS LOUISIANA	PUMPING	——	——	——	——	——	——	2-120 1-240	2 4	2 2	" "	PISTON	32-38	——	LOS GAL/ HR/HR.	000125 G/HP/HR.	SETTLING	SETTLING	1 TANK ABOVE GROUND	12 000	——	OPEN	—	110	——	NONE	——	——	——		MANIF. & EXH. PIPE	NONE

(1) HOUSE LOAD INCLUDES ALL POWER USED TO OPERATE AUXILIARIES.

(2) PLANT LOAD FACTOR EQUALS RATIO OF AVERAGE LOAD TO PEAK LOAD OF POWER PLANT.

(3) MACHINE LOAD FACTOR EQUALS RATIO OF AVERAGE LOAD TO RATED CAPACITY OF THE SPECIFIC ENGINE DURING A PERIOD OF 1 YEAR.

(4) TEMP. AT RATED LOAD.

(5) MORENCI & BISBEE PLANTS INCLUDE MOTOR DRIVEN EXCITERS. GLOBE EXCITER DIRECT CONNECTED. MORENCI EXCITATION FURNISHED IN PART DIRECT.

(6) FOR 3750 HR UNITS ONLY.

(7) SMALL UNITS 600-700°. FOR 3750 HP. UNITS, 450°-500°.

(8) UNDERGROUND PIPE FOR 6 SMALL UNITS; SOUND WAVE FILTER FOR 2—3750 HP UNITS.

(9) 750 HP. ENGINE RECENTLY INSTALLED

(10) WILL BE FULL LOADED WHEN OPERATED.

TABLE I. PRODUCTION VALUE OF ENGINES BUILT FROM 1921 TO 1927 INCLUSIVE. ABRIDGED FROM U. S. BUREAU OF CENSUS, BIENNIAL CENSUS OF MANUFACTURERS, 1927

	1921	1923	1925	1927
STEAM ENGINES				
Reciprocating				
Marine	5915612	1169702	636328	1703391
Other than marine	8774918	12882334	7962271	5405454
Turbine				
Marine	2320809			965075
Other than marine	12342587	10328268	14054879	14499006
Tractor and traction		1893280	257623	113200
INTERNAL-COMBUSTION				
Diesel & Semi-Diesel				
Marine	8273359	14012493	7352481	7061862
Other than marine	8273359	14012493	15875164	13346761
Electric-ignition types				
Aircraft				9493656
Marine	7603651	8492273	11393744	10923865
Motor-vehicle	31005352	59074245	55623879	63635746
Other types	27816559	29172683	27648576	34699391
Tractor and traction		76426406	102647205	139008715

sents a heat consumption of 9300 B.t.u. per kw-hr. Tests of the recent engines for the U. S. Shipping Board showed efficiencies ranging from 29.1 to 32.1 per cent. A single-sleeve valve, four-cycle Diesel engine designed in England by Ricardo has a guaranteed fuel consumption of 0.38 lb. per br.hp-hr.

Preference, at the present time, appears to be for the four-stroke cycle engine for sizes below 2000 hp. although a large number of two-stroke cycle engines are built in the smaller sizes. Above 2000-hp. capacity, preference is decidedly in favor of the two-stroke cycle with a steady trend toward double-acting engines for sizes above 3000 hp. Inefficient scavenging has limited the use of the two-stroke cycle. After this problem has been solved, we may expect a rapid increase in popularity of this type. Increasing complications in construction due to necessity of cooling the piston and to providing a stuffing box and crosshead, have limited the use of the double-acting type.

Research Aids Diesel Advancement

Considerable progress has been made in research projects concerning Diesel engines. Notable among these are the experiments on sprays and flame propagation carried on at the Langley Field and at the Pennsylvania State College. Vital cooperating interest in these and other similar agencies by the Diesel Engine Society would give considerable impulse and encouragement to this very important instrument of progress. Many other projects need further attention; Chapman's experiments should attract further investigation in the matter of scavenging; speed and direction of turbulence should be studied more carefully and constructional features, particularly with reference to cylinders and cylinder heads, invite improvement.

Refinements in Diesel plants are assuming the same importance found in modern steam central stations. No longer is a Diesel plant thought of in terms of engine alone. Manufacturers of Diesel engines are now going so far, in some cases, as to require a complete analysis of the water supply and similar data before they will accept orders for their product. Purification of water, based upon individual requirements, is now quite general, reducing loss of cylinder heads and cylinders and consequent loss of engine availability. Employment of full automatic lubrication and of lubricant reclamation is increasing and automatic alarms, pyrometers and gages are being installed in increasing number. In the last few years, several makes of engines have been provided with automatic devices to shut off the fuel pumps if the lubricating oil pressure at the most remote point of the system is allowed to become dangerously low.

Application of fuel oil purifiers and air filters to prevent foreign matter from entering the cylinder is now quite general and increasing in favor. Series of strainers and filters are now installed in various parts of the fuel system from the delivery into the main storage tanks, to the spray nozzles in the cylinder head.

Noise due to exhaust or air intake, has been mastered to such an extent that it is no longer necessary to be annoyed by such noises. Devices for overcoming objectionable noise have been so perfected that engine exhaust cannot be heard until the listener approaches within 15 ft. of the end of the exhaust or intake pipe. This, together with similar refinements, has made the Diesel plant unobjectionable even in residential sections.

TABLE II. DOMINANT CHARACTERISTICS OF DIESEL ENGINES BUILT BY 21 DIFFERENT MANUFACTURERS

Mfr.	Cylinder Range dia. & stroke	Crosshead or Trunk Piston	Piston Cooling water-oil	Hp. range	Hp. per Cylinder Range	Cycle	Action Single or Double	Type Fuel Inject.	Cylinder Air Compression	Compress. Press. lb./sq.in.	Fuel Inject. Press. lb./sq.in.	Normal R.P.M.	R.P.M. Range	Piston Speed ft.p.min.	Wt.per hr.-hp.	Floor space sq.ft per hr.-hp.
1	8" to 35" dia.	Both	Both	100-18000	25-1250	4	Both	Air & Solid	-			75	100-600	1600 max.	40-400	
2	6½" x 11" 13½" x 17"	Trunk	w	40-360 60-180	30-60	4	2	Solid	Piston	350-380	4000 - 4800	64-72	277-600	765-1150	100-300	
3	10.5" x 15" 20.875"x20.875"	Trunk	w - most c - largest	90-1600	45-200	4	2	Mech.	Piston	375	5000	75	200-450	735-1000	90-140	0.15-0.26
4	6" x 6½" 16" x 25"	"	w - most c - largest	25-980	12½-140	2	2	Solid	Crankcase most Scav.pump largest	300		31-55	257-500	700-874	81-345	0.27-2.5
5	23½" x 27½" 36" x 45"	Crosshead	w	1200-120	600-1000	2	Both	Air	Piston	1000	1000	65	90-180	650-1100	100-250	
6		Trunk	Air	92-180	23-30	4	2	Mech.	"	365	5500-5000		600-1000	1300-1450		
7	17" x 23" 30" x 44"	Crosshead	Both	600-4000	220-675	2	2	Air	"	470			125-257			
8	5" x 7" 16" x 18"	Trunk	w - most c - large.	16-3000	16-250	Both	2 & opposed	Solid		372-400	4500	72-100	500-1500	1300-1800	10-30	
9	13" x 16" 14" x 18"	"		45-360	45-60	2	2	"	Crankcase	500			257-300	770-900		
10	6-5/8"x8-1/8"-3 8½" x 12½"-4	"	None	25-20-2 50-150-4	12½-2 25 -4	2 & 4	2	"	"	450-2 450-4	1000 - 2 3000 - 4	40 - 2 60 - 4	425-500-2 360-400-4	610-717-2 720-858-4	180-2 138-4	
11	14½" x 18" 22" x 30"	Crosshead	None	130-1320	65-190	4	2	"	Piston	350	1800	65	180-300	831-1000	400-220	0.62-0.38
12	9½" x 10½" 15" x 22"	Trunk	None	50-1800	25-188	4	2	"	"	300	3000	72-85	250-700	1190	50-198	
13	9½" x 13½" 14" x 20"	"	None	100-650	33-1/3 - 66-1/3	4	2	Air	"	475	950	75	250-420	900	130-160	0.2
14	5" x 7"	"	c	6-40	6-10	4	2	Solid	"	420		65	750		65-90 130-175	
15	14" x 21" 18" x 27"	"	None	70-540	70-110	4	2	Air		470	750-900	90	200-257	900-	200-600	1.5-1.8
16	11" x 15 19½" x 26	"	None	150-1200	50-200	4	2	Solid		350		72	200-360			
17	12½" x 16½" 27" x 32"	Trunk & Crosshead	Air-Oil-Water	150-7500	50-750	2 & 4	2	Air	Cr.case Piston Scav.p.Super ch.	480-500	900-1300	62-72	90-338	800-1100	75-250	
18	12½" x 13"	Trunk	None	25-250	25-40	2	2	Semi-Diesel and Hot Bulb Solid	Crankcase	320						
19	6½" x 8½" 10½" x 13"	"	w	10-55	10-25	2	2	Solid	"	150-250		35 27-50	257-800	700 700-874	180	0.27-2.5
20	6½" x 10" 17" x 20"	"		10-125	10-125	2	2	"	"	102-125			190-375	540-732		
21	10½" x 15" 13½" x 20"	"	None	60-180	60-60	4	2	Precomb. chamber		510		70	250-360	623-900	160-230	0.5-0.8

REFRIGERATION DEVELOPMENTS, *Past and Future*

By Rollo E. Gilmore
Vice President, Chicago, Assn. of Consulting Engineers

DURING THE PAST decade, the refrigerating industry has kept pace with ever changing requirements and, in a measure, anticipated them. This has been accomplished by improved design, development of new apparatus and the application of advanced engineering knowledge. The main improvements by the trade have been toward design for better economy of operation, ease of cleaning, noiseless operation, conservation of space, lower first cost, lower maintenance, positive means of lubricating, temperature control, safety equipment, automatic control and measuring devices. Multiple refrigerator temperature control with one machine is now possible with positive operating equipment. It is probable that the Silica-gel adsorption refrigerating system recently developed and given various practical tests will be further improved and become as popular with some engineers in the next few years as the older systems.

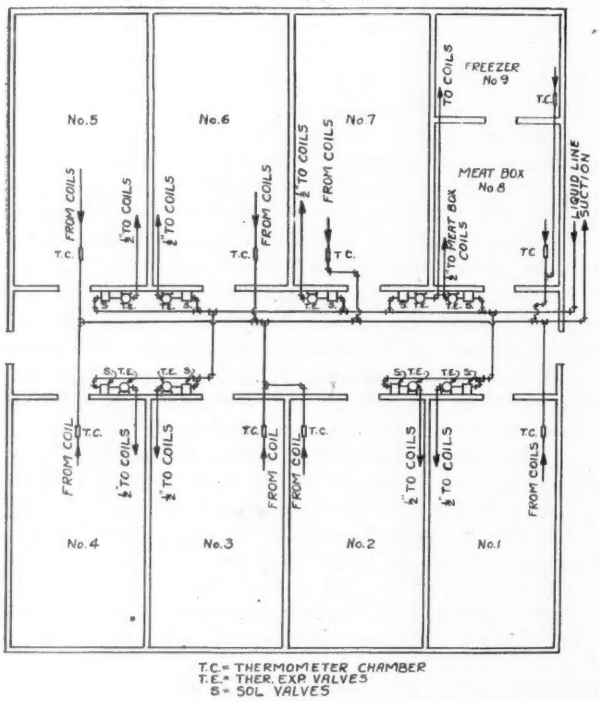


FIG. 1. VERTICAL SHELL AND TUBE CONDENSERS, 200 T. EACH IN 4000-T. PLANT

Compression and Absorption Systems

Since most of the refrigerating equipment today is of the reciprocating type compressor using various refrigerants, we will give it first consideration regarding improvements, as it has been more generally adopted than other types The tendency is toward higher speed compressors, mainly because of space requirements, which results in increased tonnage with lower first cost. This involves improvements in design of slow speed machines, such as lighter moving parts, increased valve area, lighter valves and improved lubricating systems. This type of compressor especially for high pressures is seldom kept up to to capacity by its operators, due to the valves, cylinder rings, stuffing boxes, lubrication system, gaskets and packing not being kept in proper working condition, allowing constant leakage of the refrigerant.

Centrifugal type refrigerating systems use various special refrigerants and a single multi-stage, high-speed centrifugal unit without valves, which has the general appearance of a turbine. This type of machine operates usually at atmospheric pressure, or less, and with the special condensers and evaporators is being used in some large air conditioning projects, cold storage and special cooling work.

Absorption type refrigeration systems are being used and are still popular in many places where operating conditions are favorable. While the absorption system is more expensive, it has the advantage of low operating cost where excess exhaust steam is available as a by-product, and is popular in large industrial plants, public buildings, and the like. This system has few wearing parts and repairs consist mainly of renewing pump packing and occasionally the tubes. While no radical changes have occurred in the design of absorption machines, some improvement has been made to increase economy and lower the first cost and the space required. Absorption machines are also designed to operate two-stage with satisfactory results.

Improvements in compressor design have been noted, as many manufacturers have adopted a simple geared internal positive forced-feed oil pump lubricating system driven from the main shaft with suction through fine oil filter from crank case, which delivers oil to main header pipe under constant regulated pressure to each of the main bearings. The main bearings spread oil over the journal and through drilled crank shafts to crankpin bearings, and through drilled connecting rods leading to piston pin bearings and this works out a film of oil sealing the piston rings and preventing wear.

Some manufacturers have designed their compressors, for plants maintaining relatively high and low temperatures, for compound and multiple effect compression to reduce the power requirements such as high compression ratio for two-stage and an approximately equal proportion of high and low-temperature load for multiple effect. The machines have two suction inlets

operating on independent sets of coils, or cooler fed by separate expansion valves and at different back pressures. In ice-making plants, with this equipment, the ice-can filling water supply is forecooled and the liquid ammonia is precooled, on its way from the receiver to the coils or cooler in the freezing tank, maintaining a suction on the multiple effect of 50 lb. gage.

Most small compressors under 50 tons are being installed using short belt centers, without idlers, with multiple V-type rubber, cord and fabric composition belts on multiple V-groove pulleys. Many compressors over fifty tons have direct connected engine-type motors, synchronous where alternating current is available or compound wound for direct current. In practically all cases, the flywheel effect of the compressor is built into the rotor of the motor, resulting in additional saving of floor space. There is a tendency toward electrification of present steam plants due to considerably lower power rates. Some steam-engine-driven compressors are still being installed, where the exhaust steam is required the year around and where water conditions are so bad that clear ice cannot be made except with distilled water.

Adsorption by Silica Gel

The silica gel adsorption system of refrigeration, using silica gel as the adsorbent, sulphur dioxide as the refrigerant and air cooling for the condenser and adsorbers, has recently been developed and installed, both commercially in buildings and for refrigerating freight cars and motor trucks. Silica gel is a hard glassy material with an appearance of clear quartz sand. The apparatus consists essentially of three main parts—namely, the adsorber (containing the silica gel), the evaporator and the condenser. It may be briefly described as being identical with a compression type machine, the compressor being replaced by the adsorber; the adsorption of the refrigerant vapor by the silica gel corresponding to the suction stroke of the compressor and activation of the silica gel to the discharge stroke. No power need be generated for the silica gel system, the necessary heat being applied directly to the silica gel. The adsorber is made up of many tubes of small diameter, which contain the silica gel, to effect a rapid heating and cooling. The box temperature may be regulated within 2 to 3 degrees, through the automatic thermostat controlling the flow of fuel gas to the burners, where a continuous burning pilot flame is maintained.

Condenser Changes

Present tendency in condenser design is toward the use of horizontal enclosed tubular multi-pass condensers, with parallel feed, possibly because they require less floor space and are also adaptable to bad water conditions. Where ample water is available, the three-pass multi-tubular type is used and, where economy in water is desired, the seven or larger pass multi-tubular type is used but produces more friction. In plants, generally, of over 25 tons, the vertical single-pass tubular type condenser has been widely adopted. The shell and tube type condenser also becomes added receiver capacity where so desired. Installations using atmospheric parallel-flow type, the atmospheric bleeder type and double pipe counterflow condensers are few. No doubt in a small space of time they will be obsolete, as each has certain disadvantages.

In some instances, vertical trunk type coils have been built in the freezing tanks and totally enclosed to withstand the brine pressure head, in order to obtain high velocity of the brine with a high rate of heat transfer. The latest design in this trunk type coil is the "Herringbone" made up with single, double and triple pipe coils. The float liquid control, without use of an expansion valve, maintains a constant level of ammonia. Float valve control in flooded ammonia systems has met with success using a high or low-pressure float valve to regulate the liquid level of the refrigerant. It is well known that the dead (or flash) gas, pulled through the entire length of the evaporating coil is an enormous waste of power and that a large percentage of evaporator coil is filled with dry gas that does no refrigerating work but is crowding the liquid refrigerant from the walls of the pipe and reducing its ability to absorb heat.

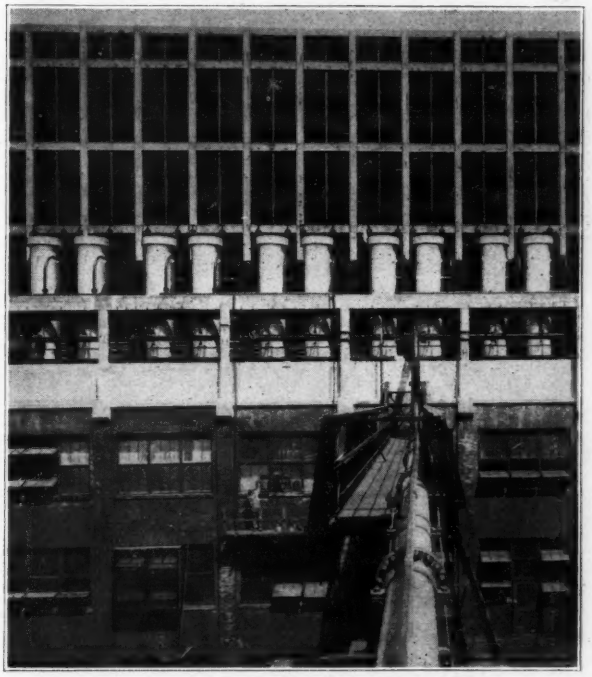


FIG. 2. MULTIPLE CONTROL OF TEMPERATURES FROM SINGLE COMPRESSOR

In the flooded system the entire surface is practically flooded with liquid, the design of the coil being such that the gases quickly reach the suction header. In this system a high-pressure float valve keeps the condenser drained so that all liquid is in the low side but its design does not permit gas to blow through. A low-pressure float valve is also used to control the liquid level in the evaporators, no expansion valve being required with these systems. This high-pressure float valve consists of a heavy semi-steel shell designed for the liquid, containing a specially designed ball float and a special valve stem and seat to control the liquid flow, also a small unloading valve, so that a vacuum may be pumped on the float valve when desired and so as to release the pressure should the valve become gas-bound.

Improvements in thermostatic valves for evaporator unit temperature control, have been made. The ther-

mostatic valves with filter ahead of them are installed outside of the boxes to be cooled and are connected up through pilot tubing to a connection made into the low side of the evaporator coils, Fig. 2. A magnetic or solenoid stop valve, for ammonia or brine, may be installed ahead of the thermostatic valve to control the box temperature. On the liquid side of these valves and on the evaporator side, hand-operated shutoff valves should be provided.

Brine Coolers

Brine coolers using floats to maintain the liquid level have been installed, which maintain a practically flooded condition without endangering the compressor and thereby lower the brake horsepower per ton, due to the

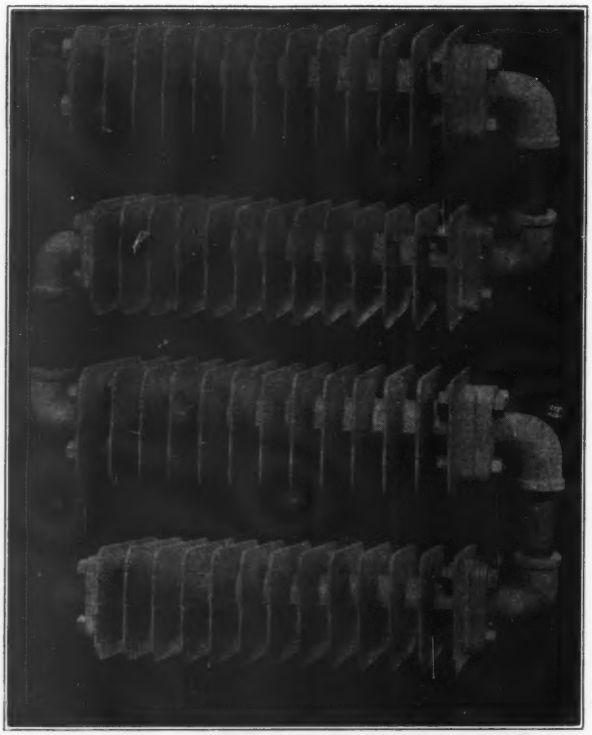


FIG. 3. EVAPORATOR SECTIONS, 6½ SQ. FT. CAPACITY = 19 FT. 1-IN. PIPE. WEIGHT 40 LB.

greater efficiency of the cooler. Horizontal tubular type brine cooler installations are being more widely used than the tubular pipe or spiral coil and tank cooler. The horizontal tubular type of brine cooler has less friction loss. In the large majority of ice tanks using the shell and tube cooler design, the cooler is a horizontal, single-pass, open type, operated on the flooded system, with a suction accumulator to prevent liquid ammonia getting back to the compressor.

On the low side, the evaporators have been improved by the use of plain, webbed and finned cast-iron sections made of a special grade of cast iron, Fig. 3.

Building Refrigeration Systems

Many multiple direct expansion methyl-chloride central refrigerating systems in buildings, such as apartments up to twelve stories, using extra heavy steel pipe and extra heavy fittings, have been installed. Many of these systems use steel pipe with all lines welded that fittings are eliminated, except the connections at the refrigerator, and there is little possibility of leakage. These are of two-pipe systems, tested to 250 lb., without insulation. The evaporating coils or cooling units in these systems are usually small size pipe coils or cored castings, especially designed for the pressure and installed in the boxes in a manner to permit freezing two or more ice cube trays. The trays generally used are of copper, tin, aluminum or rubber. This system, although economical, has caused much criticism and discussion, with many proposed revisions of codes and ordinances pertaining to the refrigerant gases and their installation.

Now being recommended by some, is a proposed direct-expansion primary copper tube system with heavy steel plate evaporators having welded joints and with a substantial gas-tight secondary iron pipe system with sealed junction boxes, to enclose the primary system fully and equipped with a valved vent to the outside air. The iron pipe enclosure would start at the compressor, which would be in a separate machinery room, vented to the highest point outside of the building, and run up to the heads of the evaporators, utilizing special valve and junction boxes.

Calcium Chloride Brine

Until recent years, the granulated form of calcium chloride was the only type on the market. Now this also comes in the form of loose flake calcium chloride put up in 100-lb. moisture-proof bags and 350-lb. drums, which simplifies the labor in preparing and quickens the time for going into solution. On new work it is advisable to treat calcium brine with ordinary CO_2 gas to remove excess alkalinity. The foaming of brine is often caused by weak brine and, by strengthening this with the addition of calcium chloride, the air is forced out of the solution. Where froth or foam appears in an old brine system, it is an indication of corrosion taking place, or that an excess of air is being introduced into it. Numerous rust and corrosive preventive compounds are on the market, many of which have sodium silicate or water glass as a basis, and are useful in clarifying the brine. Sodium chloride brine may be tested for ammonia by the use of Nesler's solution, which is a sensitive indicator for detecting ammonia in water and in salt brine and with a slightly different mixture for detecting ammonia in calcium chloride. Ammonia leaks also increase the rate of corrosion, although they have no effect on the brine itself, other than increasing its alkalinity.

Metering Refrigeration Service

In many plants where it is desired to know the cost of refrigeration service, especially where serving several properties or tenants, the liquid ammonia or brine is being metered, Fig. 4. A Venturi tube flow nozzle, or orifice with V-tube is installed in the line to the evaporator, or orifices on brine systems to check continually the rate and quantity of refrigeration supplied by the compressor, through electrical or mechanically operated fluid meters, which are had in indicating, integrating and recording types. This guides the operator in regulating the expansion valves to the rate at which the ammonia is circulated and reduces the possibility of the liquid slopover, which might be returned to the com-

pressor. Differential temperature recorders are also used to measure rise in temperature between brine entering and leaving customer's premises.

Some of the safety devices for the refrigerating machinery room where inflammable refrigerants are used, consist of closed and oil-immersed motor switches with separate emergency switch, outside of machinery room. In methyl chloride systems the addition of methyl nitrite, sulphur dioxide, ammonia, or other similar odorant gases are being adopted as a warning in the detection of leaks.

Insulation Media

In the insulating of cold storage plants no improved material has been noted. It is predicted that in the future, particularly in low temperature, the insulation will be protected completely against the entry of water vapor, probably by carefully sealing the outside of the insulation space with integral covering such as suitable character of asphalt rolled on to a well-infused paper under both pressure and the proper degree of heat. The most radical departure in insulating large ice storage houses consists of the erection of two concrete walls with a 12-in. space between them for granulated cork. Although more expensive than sheet cork insulation, it is claimed by its proponents to have a much longer life.

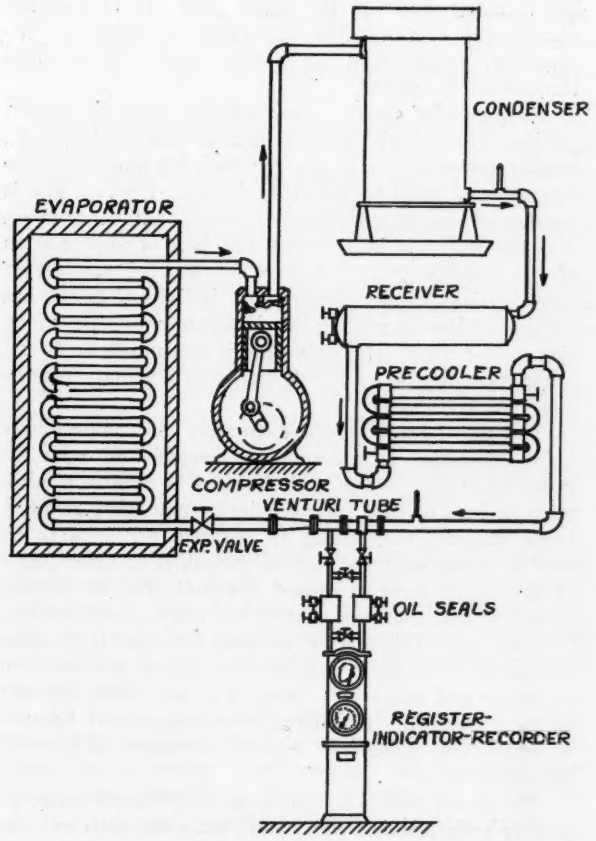


FIG. 4. SYSTEM FOR METERING REFRIGERATION SERVICE

For cold pipe insulation, no new methods have been used. Cork covering and fittings of pure granulated cork, moulded and baked with mineral rubber finish are generally used, with hot parafine mixed with fine granulated cork for large fittings instead of the cork putty formerly used. Some engineers prefer the built-up felt insulation of two, three, or four layers (2, 3 and 4 in. thick) over pipe and a waterproof membrane, oiled paper, rosin sized paper and a canvas jacket. With expert workmen applying this material, a good covering is produced.

Where no pipe tunnels were available, underground brine line installations have been made using a special split type underground tile and, in some cases, iron conduits, with bell joints and drainage base, concrete foundations, brine thickness cork insulation. supported on metal plate and pipe rollers. The horizontal side joints, bell joints of tile and holes in bottom half sections, were cemented up and hot mopped with pitch, making moisture-proof construction.

Future Development

Few ice plants are being installed at present, due to the spread of household and small commercial machine installations. Because of this, the existing ice plants are so improved as to cut down operating expense to a minimum. This has been accomplished by the use of the multiple can pull, either half or a whole row. The machinery is being simplified so as to require minimum of attention.

In the future plants will probably be of considerably smaller capacity, made to operate automatically so that one man can take care of them, performing the duties of operator and clerk.

Larger packing plant manufacturers are now experimenting with quick freezing of their product. This is accomplished by slicing the product thin and freezing at low temperatures. It is claimed that the product has a much better taste because of the quick freezing and the frozen product can be delivered to retailers in ready made packages for the use of the consumer.

In the ice cream industry a new improvement is the use of iceless trucks for delivering ice cream to retailers. On the truck is mounted a well insulated refrigerator, which is cooled by a small refrigerating machine while in transit. The retailer either has a mechanically cooled cabinet or uses the Waltham process which consists of frozen brine in arc shaped containers made to fit the outside of the ice cream can.

Manufacture of dry ice is on the increase. While no one can foretell just what position it will reach in the industry, many trucks are now refrigerated by means of dry-ice, especially in the large cities where dry-ice manufacturing plants are in production. This method reduces the delivery cost, owing to the reduction in the size of the truck, made possible by a large reduction in weight carried. Dry-ice is coming into popular use, especially among the ice cream retailers. By the use of special cardboard cartons, any size package from a pint to a gallon can be delivered to a home in a dry condition and kept in good condition from three to four hours before being used.

It is generally felt by prominent engineers that high or super pressure boilers for over 2000 lb. per sq. in. will be of the flash type, with small tubes, no header, no drums and all welded joints, consisting of a single coil for small outputs and multiple coils for large outputs.

Editorial Comment

Factors Involved in the Design of Power Plants

Arguments between the proponents of the privately owned plant and those of central station service have long waxed hot and furious and probably will continue as long as these two classes of service exist. It is not our purpose here to stir up the controversy again but recently we came across an instance where a small privately owned plant was built in the face of central station rates which were below those at which the new plant could generate power, yet a considerable saving was effected.

This case involved the construction of a 150-kw. generating plant for supplying power to a furniture factory. The plant had been using purchased power. When the question of building this plant came up, the consulting engineer retained to design it, after making a preliminary investigation, decided that because of the low rates of central station power prevailing the owners were not justified in building a plant. He, therefore, recommended the use of purchased power. He showed that the interest on the investment together with the cost of operating a small plant of this type would be in excess of the amount necessary to purchase all power required from the local utility. But the owners would not take no for an answer and were insistent in their demand for a private plant. So the consulting engineer made further studies but under no conditions could he justify the construction of a plant.

Finally, however, it developed that, when using purchased power, the plant had suffered a number of shut downs during previous years due to the failures of transmission lines. This plant is located in a remote section of the country and the service apparently is less reliable than in more densely populated sections. When the cost of these interruptions of service were considered in terms of loss of production, it was evident that, notwithstanding the extra investment required, money could be saved by building a private plant. Results obtained in the operation of this plant thus far seem to have justified that conclusion.

This, of course, is only an isolated case and no general conclusions must be drawn from it. Our purpose in presenting it is merely to point out that every possible condition must be considered before making a decision either to buy or generate electric power. In another location, where power service was more reliable, the construction of this plant would not have been justified.

Help to Build the Industry

Definite need usually gives an industry its initial start and various agencies contribute impetus to its growth but a strong factor in the building of any industry which may be aided by any individual in the industry but which too frequently is ignored, is coöperation, whereby each contributes to a common pool data that, being properly analyzed, increases general knowledge concerning plant operation, hence improvement of service and decrease in costs.

Recognition of the value of this kind of coöperation by the National Electric Light Association, particularly by the Prime Movers Committee of that association, has resulted in much benefit not only to its own members but to many others in the power field. In this particular as well as others, this association has made an outstanding contribution to power plant development throughout the world.

Managers of large power plants, such as central stations, particularly those connected with the N.E.L.A., readily respond to requests for data for analysis while managers of small plants often do not. Perhaps this is because of lack of systematic records but in other cases, it is likely due to indifference and lack of appreciation of the benefits derived from whole-hearted support of investigations of this kind. The individual plant has nothing to lose by adding the data concerning its operation to the pool. If much time is consumed in assembling such data, it is a sure sign that adequate records have not been kept.

Instead of ignoring questionnaires concerning power plant operation, as presented by responsible organizations, when they are in such form as to require a minimum amount of time for compliance, managers of many large stations, responding to requests for data to be used in power analyses such as published on other pages of this issue, have expressed gratitude for the opportunity to add the data concerning their plants, saying, "We are glad this matter has been brought up because we should have all of this data on record for our own reference and analysis." Some who have been left out of such published lists have even complained because of what they considered was an oversight in the collection of data.

The power field is becoming more and more complex; greater refinement of equipment, more complete records and better operating efficiency, are increasingly required to reduce costs. Everyone in the industry may well heartily contribute his mite in order that the power industry may function as competently as possible.

Off Duty

One of the most interesting examples of the manner in which a problem of scientific research starting with a definite idea may lead into unforeseen channels is told in an article in the current issue of the National Geographic Magazine. This article describes the results of a series of investigations of tree rings in the southwest made by Andrew E. Douglas, director of the Steward Observatory at the University of Arizona. How this astronomer was led from the study of sun spots to the cutting of tree and timber sections and how this work pushed back the horizon of history in the United

States nearly eight centuries before Columbus is a fascinating story—one worthy of the admiration of any lover of method. But perhaps we are getting somewhat ahead of our story. In the first place, maybe we had better explain what we mean by tree rings.

Tree rings are the concentric rings which are displayed on a section of a tree trunk when it is sawed in two. These rings, as you know, constitute a sort of calendar, for each ring represents one year's growth in the life of a tree and by merely counting them we can determine accurately the life of the tree. Throughout long past ages and with unbroken regularity, trees have jotted down records of their lives. This much has been known a long time and it is by counting such tree rings that the ages of the giant Sequoias in California have been determined. What was not known until quite recently, however, was the fact that these rings, in addition to telling us the history of the tree itself, also told something about the conditions existing on earth throughout the life of the tree.

If every year were exactly the same, the growth rings in a tree would merely tell the age of the tree and nothing more. But as Dr. Douglas, asserts, a tree is not a mechanical robot; it is a living thing and the story of its food supply and its adventures through life all enter into its diary.

In the arid regions of our southwest where trees are few and other vegetation scarce, the most important thing to trees is water or rainfall. So, in the rings of the tree historian, we find lean years and fat years recorded. In years of little rainfall, the tree does not grow much and the rings formed are close together. When rainfall is plenty, the rings are far apart. Thus in examining the various trees in the same forest, we would find the same succession of drought and plenty recorded in unmistakable sequence.

It was this fact which led Dr. Douglas from a study of sun spots to a study of tree rings. Sun spots, it is well known, affect to some extent our climate and thus the rainfall. Now, sun spots undergo an eleven-year cycle; that is, they are most numerous at intervals of eleven years.

As an aid in his astronomical work in this connection, Dr. Douglas turned to a study of tree rings and upon investigating found, as he had expected, that there was recorded in the tree rings an eleven-year cycle which was coincident with the sun spot cycles.

In this work, when the earliest date recorded by the oldest weather recording trees in Arizona had been reached, it became necessary to search for beams and timbers that had been cut by man before the oldest trees took up the story. Here and there they found beams, among the ruins of ancient Indian Pueblos the latter years of which were contemporaneous with the early years of trees still living. In this way, the chronology of this region was extended steadily until finally a beam was found whose earliest ring was formed A. D. 1260.

In the course of these studies, Dr. Douglas found a complete record of the eleven-year sun spot cycle, throughout the entire time interval with one notable exception. It was noticed that between the years 1650 and 1725 there was no evidence of the regular sun spot cycle. This seemed strange but no explanation was had until several years later, when an eminent English astronomer unaware of Dr. Douglas' findings, wrote him that from a study of old astronomical records he discovered that there were no sun spots between 1645 and 1715, and that if the tree rings did not indicate some effect of this absence, the work was being conducted on an erroneous hypothesis.

This coincidence between the failure of the Arizona trees to register a sun spot effect upon the weather, and the establishment of the fact by an entirely independent method that there were no sun spots during the same period was a remarkable corroboration of the correctness of the idea.

Having established these facts, it was only a step further to reason that the comparative ages of various ancient Indian ruins could be arrived at by a study of these same rings. For if the rings in a certain prehistoric roof beam correspond to certain years of drought or plenty, then surely it is easy to tell when that tree was cut for the purposes of building. Thus the tree rings were applied to the archealogy.

One of the major questions which had confronted the archealogists in the southwest was the age of the Pueblo Bonito, the oldest and largest of the great Indian communities in Chaco Canyon, New Mexico. Primarily to solve that problem, the National Geographic Society invited Dr. Douglas to undertake the investigations which not only gave the answer to this but what was for more important it gave a chronology extending back to the year A. D. 700, eight centuries before Columbus. It was shown that the earliest beam that had been recovered from Pueblo Bonito had been cut A. D. 919 from a tree that was 219 years old when cut.

There are the bare facts. The fascinating story of the actual discovery of Beam HH39 which gave the final solution is too long to be told here but this will serve to indicate the manner in which this study was conducted. What the discovery of the far-famed Rosetti Stone was to the extension of our knowledge of early Egyptian history, the finding of Beam HH 39, as it was classified, is to our southwestern archealogy.

MISSOURI UTILITY NEWS says that a guest at a recent demonstration illustrating laboratory achievements by electric and telephone engineers was amazed when:

He "heard" a picture of President Herbert Hoover.
He heard a speechless man "speak."
He saw a deaf man "hear."
He heard the power of 500,000 times 50 strong-lunged men's voices shout the words of one man.
He heard his muscles move, with a sound like thunder.
He telephoned his photograph.
He learned it is possible to gaze at a scene many miles distant.
He heard speech "scrambled" as a cook scrambles eggs.
He danced to "upside down" music and heard speech "upside down" and "right side up" at the same time.
He was looked over by an electric eye.
He saw and heard speech "take a rest" on the route from lip to ear.
He talked into a telephone and then walked over to the other end of the line and listened to his own words four seconds after speaking them.

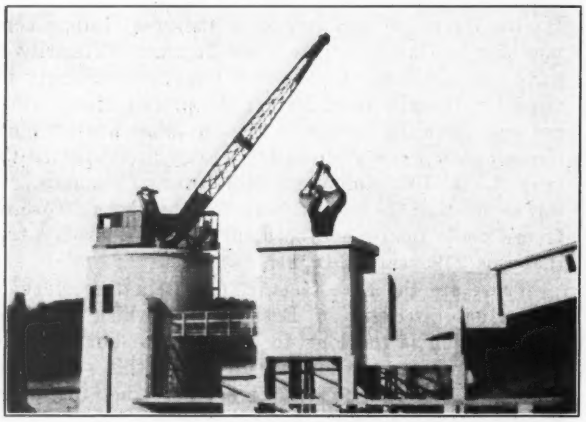
"Such is modern progress," says the Utility News.

Power Plant Engineering Developments and News

Coal Unloading Plant

COAL FROM river barges of 400 t. capacity is handled by the grab-bucket crane installation shown herewith at the plant of the Gulf States Service Co., Holt, Alabama.

Support is by a hollow concrete structure which encloses a water intake screen, thus saving foundation costs. Controls are located well forward on the tower,



CRANE ON SPECIAL MOUNTING HANDLES COAL FROM RIVER BARGES

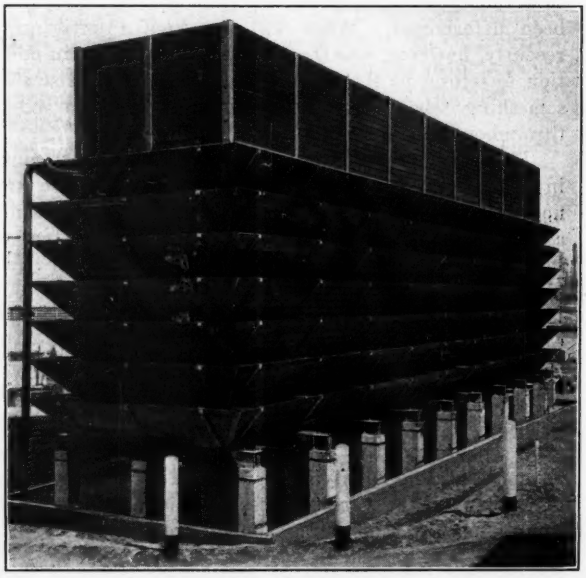
inside the structural steel crane housing, so that the operator has, at all times, a clear view of work on the barge below.

Delivery by the crane is to a hopper inside the square tower with feeder to a crusher, thence by conveyor to the stokers or to storage. For capacities under 50 t. an hour, the equipment is stated to work out more economically than a stationary unloading tower, at the same time providing for considerable variation of the river level. The installation was made by the Link-Belt Co. of Chicago.

Marley Spray Deck Towers

FOR USE where cooling towers of high capacity and efficiency are required, the Marley spray deck tower shown here has recently been placed on the market. This tower is a conventional form of deck type cooling tower with a spray cooling system in the top to give better breakup and distribution of the water. This spray system is designed to replace troughs, launders and flumes.

This tower is designed so that water is stopped, broken up and started again at every deck and so that none can drop straight down through the decks. Fifty per cent free air passage is obtained, it is stated. Marley spray nozzles are used to provide a fine, uniform spray at low pressure.



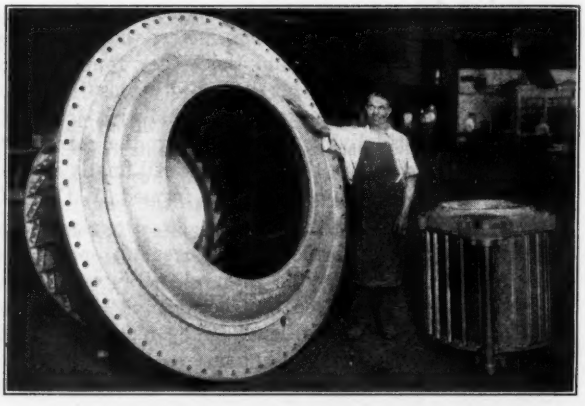
SPRAY DECK TOWER OF OVER 1000 G.P.M. CAPACITY

The tower is braced horizontally and vertically and main members are securely bolted with galvanized or bronze bolts. Main tower footings are anchored to foundations by cast-iron base plates. Louvers are provided in panels of convenient size.

This spray deck tower is a product of The Marley Co., Kansas City, Mo.

Large Separator Unit

ONE OF the largest centrifugal type internal separators ever built has just been shipped by the Centrifix



CENTRIFIX 42-IN. CENTRIFUGAL SEPARATOR

Corp., Cleveland, Ohio, to a large alkali works. It is a 42-in. size, the larger of the two units shown in the accompanying cut. These separators, for evaporator service, when installed in the pans prevent entrainment from going over into the next effect or being lost in the condenser. Centrifugal motion is imparted to the vapor by passing it through a system of fixed tuyere blades tangentially arranged in ring formation, thus giving the vapor a whirling motion which separates its various components.

News Notes

NATIONAL MAZDA LAMPS now take the name of the General Electric Mazda lamps, according to a recent announcement by the National Lamp Works of the General Electric Co., Cleveland, Ohio. The lamps will be sold by the National Lamp Works with the same organization and through the same channels that distributed Mazda lamps. The Edison Lamp Works of the General Electric Co. will continue to sell lamps under the name of Edison Mazda lamps.

HILL EQUIPMENT ENGINEERING Co., 4620 Delmar Blvd., St. Louis, Mo., has been organized by Lockwood Hill to handle sales of the products of the Lincoln Electric Co. and the Baker Industrial Truck Co. in eastern Missouri and southern Illinois.

IN A TEST authorized by Matthew S. Sloan, president of the New York Edison Co. and associated electric light and power companies, coal that was in the mine in the mountains of West Virginia on Tuesday, November 19, was, on Friday, November 22, being fed under the boilers of one of the power plants of the system. The test was carried through by W. W. Erwin, controller of the New York Edison Co. and officials of the Pocahontas Fuel Co., 1 Broadway. The order consisted of 6000 t., or a train load of 75 cars. Mined on November 19, the coal was immediately loaded into cars and transported the 400 mi. to Norfolk, Va., by the Norfolk and Western Railroad. In 3 hr., it was dumped into the hold of the fuel company's collier Bylayl, which started at once on its 300-mi. journey to New York. Friday afternoon, the Bylayl steamed up East River to the Hell Gate Generating Station of the United Electric Light and Power Co., located in the Bronx on the waterfront, docking at 3:10 p. m. At 3:15 p. m., the coal was being conveyed to the bunkers, on its way to the boilers. The system of five companies in New York has an average weekly consumption of about 70,000 t. of coal, and the purpose of the test was to establish the minimum time in which unmined coal may be put to the service of New York City in the generation of electricity.

GENERAL REFRACTORIES Co. has recently appointed the Paxson Taggart Co., Luzerne and D Streets, Philadelphia, Pa., as exclusive dealer representative in the Philadelphia district, the surrounding counties of Chester, Montgomery, and Bucks and the southern half of New Jersey.

WILLIAM J. BUSH has recently resigned from B. F. Sturtevant Co. with which he has been located at Birmingham, Alabama, as district manager, to take a position as a building service engineer in the structural division of the Stone & Webster Engineering Corp. at Boston.

WILLIAM F. RYAN has joined Stone & Webster Engineering Corp. at the Boston office as engineer in the mechanical division, coming from the engineering departments of the Solvay Process Co. and Atmospheric Nitrogen Corp., with which firms he has been connected since 1924.

ROY F. BURKHART, for the past two years electrical engineer in operation and maintenance department of the United Gas Improvement Co., Philadelphia, Pa., has recently accepted a position as engineer in the electrical division of Stone & Webster Engineering Corp. at the Boston office. Mr. Burkhart has had broad experience in electrical engineering and construction work, having held responsible positions with the American Gas Co., Philadelphia, Pa., Luzerne County Gas & Electric Corp., Kingston, Pa., Cedar Valley Electric Co., Charles City, Iowa, and Western Electric Co., Chicago, Illinois.

THORN DICKINSON, since 1925 with Ulen & Co. on foreign construction work in Greece and Poland, has joined the Stone & Webster Engineering Corp. as engineer in the structural division. Previous to his foreign service, Mr. Dickinson was assistant with T. R. Atkinson, civil and consulting engineer, Bismark, North Dakota.

HISTORICAL AND EDUCATIONAL EXHIBITS showing the progress of heating and ventilating are being sought by the management of the International Heating and Ventilating Exposition to be held at the Commercial Museum, Philadelphia, during the week of January 27-31. A special section is being set aside for the purpose of making the exhibit one of the most complete and comprehensive ever gathered together. An appeal is being made not only to those within the industry but to the public for information which will lead to the location of both historical and educational exhibits which would be available during the progress of the Exposition. Information of this kind will be appreciated by Charles F. Roth, manager of the Exposition whose offices are Grand Central Palace, New York City.

HEADLEY EMULSIFIED PRODUCTS Co. on October 1 became the successor to Headley Good Roads Co. of Philadelphia, Pa. The officers of the new corporation are: president, Edgar S. Ross, director of research and development of the old company and formerly in charge of investigations on roofings and waterproofings at the Mellon Institute of Industrial Research; vice-president, Parmely W. Herrick of the Herrick Co., Cleveland, Ohio; vice-president and treasurer, M. W. Lefever, for 15 yr. in a similar position with the Headley Good Roads Co.; secretary, Geo. D. Webster of Cleveland.

GENERAL REFRACTORIES Co. has recently appointed the Bison Builders Supply Co., 1345 Genesee St., Buffalo, N. Y., as dealer representative in Erie County, New York State.

C. R. MATHENY has joined the sales department of the Stratton Engineering Corp., 116 East 18th St., New York. He was formerly New York district manager of the Hagan Corp.

RICHARD HOWARTH, master mechanic at the Rhode Island Malleable Iron Works and formerly consulting expert on the editorial staff of Power Plant Engineering, died at his home in Norwood, R. I., Nov. 11, 1929. Since July 30, he had been confined with cancer. He is survived by a widow and four sons. His helpful articles on the use of the slide rule and on marine power plant operation will be well remembered by readers.

IMPROVEMENTS, of approximately $1,000,000 are budgeted for the Springfield, DeKalb and Sycamore districts of the Illinois Power Co. and three-quarters of this amount is scheduled to be spent in the Springfield territory, according to company officials' recent announcements. Additional boiler and generating equipment, substitution of underground cables for overhead wires and construction of many miles of rural electric service are principal works to be undertaken. Detailed plans and estimates for the projects are now being prepared by H. E. Dunn and L. E. Brown of the engineering department of the Allied Power and Light Corp.

E. C. ROHRBAUGH is now in charge of operations for the Iowa-Nebraska Light & Power Co., constructing a large addition to its Shenandoah, Iowa, power plant, having been transferred from York, Neb. Grady Fort, recently transferred to Norfolk, Neb., by the company, has resigned.

IOWA PUBLIC SERVICE Co. will spend $100,000 upon improvements of its Audubon, Iowa plant this winter, Fred Plaehn, district superintendent, has announced. Steam equipment will be replaced by a Diesel engine of 800 hp. capacity.

THE LIBBEY GLASS MANUFACTURING Co., Toledo, Ohio, announces with profound sorrow the death of its president, Jefferson D. Robinson, Sr., on Friday, November 8.

UNITED STATES CIVIL SERVICE COMMISSION announces open competitive examination for associate mechanical engineer, internal-combustion engine research, applications for which must be on file with the commission at Washington, D. C., not later than December 31, 1929. The examination is to fill a vacancy under the National Advisory Committee for Aeronautics for duty at Langley Field, Va., and for similar vacancies. Entrance salaries range from $3200 to $3700 a year. The appointee will, under general director but with considerable latitude for exercise of individual judgment, perform difficult and specialized thermo dynamic research in connection with internal-combustion engines of any type. Competitors will not be required to report for examination at any place but will be rated on education, training and experience. Full information may be obtained from the Civil Service Commission, Washington, D. C., or at the post office or custom house in any city.

NEW ORDERS OF 1712 steel boilers were placed in October, as reported to the Department of Commerce by 80 manufacturers comprising most of the leading firms in the industry, as compared with 1910 boilers in September and 1803 in October, 1928.

Power Plant Construction News

Ark., Waldron—The Southwestern Gas & Electric Co., Shreveport, La., is considering construction of a cold storage and refrigerating plant in connection with present ice-manufacturing plant at Waldron, reported to cost close to $30,000, with equipment.

Calif., Long Beach—The Proctor & Gamble Co., Gwynne Building, Cincinnati, Ohio, will install electric power equipment in proposed soap-manufacturing plant on tract of land acquired at Long Beach, entire project to cost about $4,000,000.

Calif., Los Angeles—The Shell Development Co., a subsidiary of the Shell Oil Co., Shell Building, St. Louis, Mo., plans installation of electric power equipment in proposed new nitrogen fixation plant in vicinity of Los Angeles, initial unit to cost about $250,000. Entire plant will be electric-operated.

Conn., Meridan—The International Silver Co. plans installation of electric power equipment in new two and three-story addition, project reported to cost more than $150,000.

Fla., Jensen—The Jensen Ice Storage Co., recently organized by W. L. Fredericksen, Jensen and associates, plans early construction of ice-manufacturing plant with capacity of about 15 tons per day, reported to cost about $35,000.

Ill., Chicago—The Dallas Brass & Copper Co., 6600 West Grand Avenue, will install electric power equipment in connection with an expansion program reported to cost close to $1,000,000, to be carried out in 1930. C. D. Dallas is president.

Ind., South Chicago—The Illinois Steel Co., Chicago, Ill., plans installation of electric power equipment in proposed one-story addition to steel mill at South Chicago, 50x300 ft., reported to cost more than $200,000.

Kan., Tecumseh—The Kansas Power & Light Co., Topeka, will proceed with addition to steam-operated electric power plant at Tecumseh, and will equip to increase capacity to 55,000 kw., reported to cost more than $100,000.

Ky., Winchester—The Hon Lumber Co., plans installation of electric power equipment in proposed rebuilding of portion of mill recently destroyed by fire with loss reported at close to $100,000.

Mass., Worcester—The Walker Ice Co., has filed plans for construction of one-story ice-manufacturing plant at 456 Grove Street, to cost about $50,000.

Mass., Worcester—The M. J. Whittall Associates, Inc., will proceed with superstructure for a two-story boiler at carpet mills on Brussel Street, to cost about $100,000. A building permit has been issued.

Me., Bucksport—The Maine Seaboard Paper Co., recently organized by Walter S. Wyman, president, Central Maine Power Co., Augusta, will install electric power equipment in proposed newsprint mill at Bucksport, entire project to cost more than $5,000,000. A boiler plant is planned.

Md., Baltimore—The Eastern Rolling Mill Co., Sewer Road, will install electric power equipment in connection with extensions and improvements in plant to cost about $300,000.

Mich., Jackson—The Arctic Ice Cream Co., 3301 Grand River Avenue, Detroit, plans installation of ice-making equipment and electric power apparatus in proposed new plant on Wildwood Avenue, Jackson, estimated to cost about $135,000.

Mich., Kalamazoo—The Paper Products Mfg. Co., Michigan Avenue, plans installation of electric power equipment in proposed addition reported to cost $135,000. Vosler & DeLoff, 230 East Kalamazoo Avenue, are architects.

Minn., Minneapolis—The Grand Storage Battery Co., 226 North Second Street, plans installation of electric power equipment in proposed addition to plant, entire project to cost close to $100,000.

Minn., Monticello—The Monticello Preserving Co. plans installation of electric power equipment in connection with rebuilding of portion of plant recently destroyed by fire with loss reported in excess of $90,000.

Miss., Walthall—The Mississippi Power Co., Gulfport, Miss., is considering the construction of a power substation at Walthall, reported to cost more than $25,000.

Mo., St. Louis—The J. R. Brockman Mfg. Co., North Second Street, plans installation of electric power equipment in proposed one-story pipe and pipe bend manufacturing plant on Market Street, entire project to cost $100,000.

N. B., Chatham—The International Paper Co., 100 East Forty-second Street, New York, plans installation of electric power equipment in proposed new newsprint mill at Chatham, for which site is now being purchased, entire project reported to cost in excess of $1,500,000.

Neb., Fremont—The City Council is considering extensions and improvements in municipal light and power plant, including new boiler unit, reported to cost close to $60,000.

N. C., Wilson—The Town Council is said to be planning extensions and improvements in municipal electric light and power plant to cost more than $250,000. A bond issue is being arranged.

N. J., Grasselli—E. I. duPont deNemours & Co., Wilmington, Del., operating the Grasselli Chemical Co., plans installation of electric power equipment in connection with expansion program at plant at Grasselli, near Linden, entire project reported to cost more than $1,000,000.

N. J., Kearny—The Federal Shipbuilding & Dry Dock Co. plans installation of electric power equipment in connection with shipyard expansion program reported to cost in excess of $100,000.

N. J., Wharton—The Alan Wood Mining Co., care of the Alan Wood Steel Co., Conshohocken, Pa., plans installation of electric power equipment in connection with an expansion and improvement program at iron ore properties at Wharton and Oxford, recently acquired, entire project to cost more than $500,000.

N. Y., Corning—The Corning Glass Co., will install electric power equipment in new plant addition to cost over $500,000, for which plans have been approved.

Ohio, Lorain—The Thew Shovel Co. plans installation of electric power equipment in connection with an expansion program at steam shovel manufacturing plant estimated to cost close to $100,000.

Ohio, Youngstown—The Ice & Fuel Co., 1421 West Federal Street, is said to be planning early call for bids for a new two-story ice-manufacturing plant to cost about $150,000. George B. Bright, 2615 Twelfth Street, Detroit, Mich., is engineer.

Okla., Canton—E. W. Baker & Co., Medical Arts Building, Oklahoma City, Okla., has plans under way for a one-story ice-manufacturing plant at Canton, reported to cost about $27,000, with equipment.

Ore., Salem—The Western Products Co. Salem, plans installation of electric power equipment in proposed local paperboard mill, reported to cost more than $300,000, for which plans will be completed by L. A. DeGuere, Wisconsin Rapids, Wis., engineer.

Pa., Apollo—The Apollo Steel Co., Apollo, will install electric power equipment in connection with an expansion program in mill at Vandergrift, entire project reported to cost more than $600,000. A. M. Oppenheimer is president.

Pa., Etna—Spang, Chalfant & Co., Pittsburgh, will install electric power equipment in connection with extensions and improvements in tubular products plant at Etna, project to cost close to $400,000.

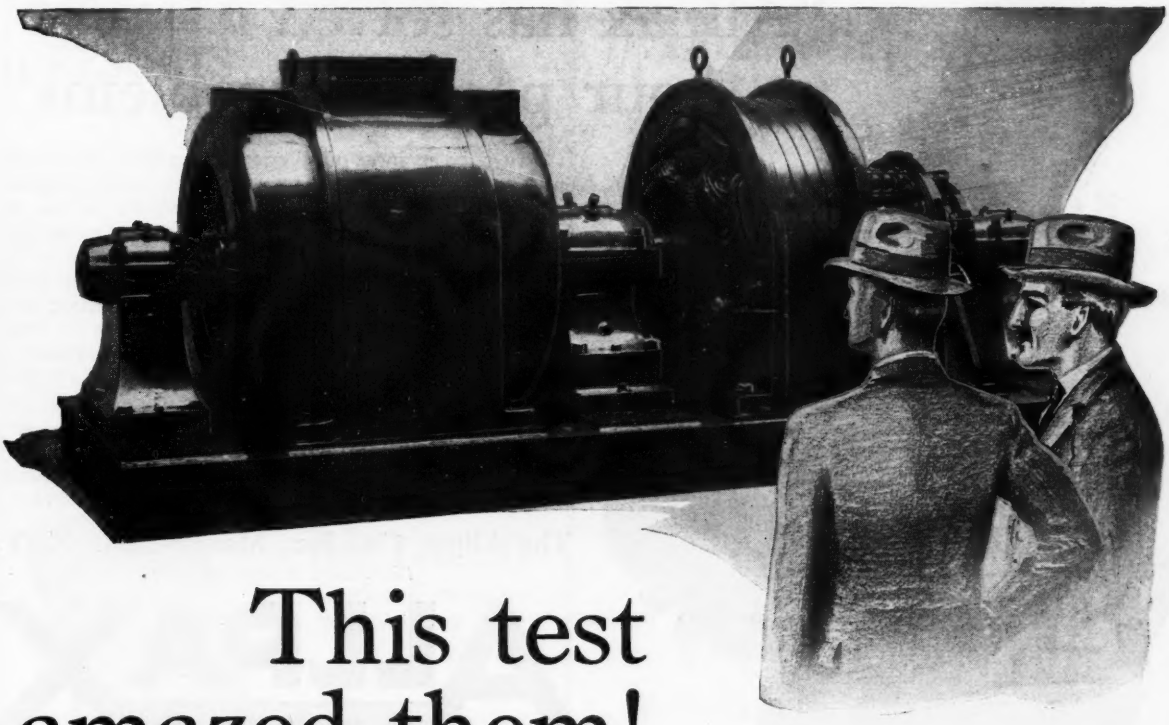
Texas, Dallas—The County Auditor, Dallas County, Court House, will receive bids until Dec. 9, for one air compressor for engine room in the Criminal Courts and Jail Building, as per specifications on file.

Texas, Mount Pleasant—The Texas Milk Products Co., Marshall, plans installation of electric power equipment in proposed milk processing plant at Mount Pleasant, entire project to cost about $150,000. A boiler plant is planned.

W. Va., Maybury—The Mill Creek Coal & Coke Co., plans installation of electric power equipment in connection with proposed rebuilding of tipple at its Elkhorn Colliery, Maybury, recently destroyed by fire with loss reported at close to $100,000.

W. Va., Weirton—The Weirton Steel Co., Weirton, will install electric power equipment in connection with an expansion and improvement program at local mill to cost close to $5,000,000, including new buildings, blast furnace and other units for large increase in output.

ELLIOTT for Motor Generators



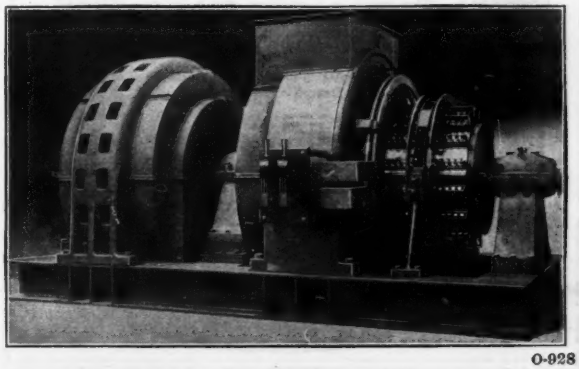
This test amazed them!

A group of prospective purchasers was observing the test of a 300-kw. set in the ELLIOTT shops. Step by step the normal load of 1090 amperes was increased—to 1500 amperes—to 2000—to 2500 and then finally to 3000 amperes, and held there for five minutes. 175% overload, and the ELLIOTT Motor-Generator set gave no sign of distress!

Sound design, exceptionally generous factors of safety, good, clean, careful manufacturing — without these ELLIOTT equipment could never have built the unusual reputation it has for unfailing service under the most trying conditions.

An overload of almost three times normal load could not distress this ELLIOTT Motor-Generator Set.

Elliott Motor-Generator Sets are built in a complete range of sizes, up to the largest. A 1500-kw. Set is illustrated below.



If you are interested in motor-generator sets that are rugged, economical, and competent, investigate Elliott.

ELLIOTT COMPANY
PITTSBURGH, PA.
General Sales Offices **JEANNETTE, PA.**
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Elliott Power Equipment includes engines, turbines, motors, generators and electrical machinery, condensers, deaerators, heaters, centrifugal blowers and accessory equipment.

O-928

"Allpax has solved our packing problems"

writes the engineer of a large concern using ALLPAX on centrifugal and direct-acting pumps, steam engines, valves and other equipment. This report is one of many enthusiastic letters we have received commending ALLPAX for all types of packing service—even under severe operating conditions where no other packing could be kept tight without excessive pressure and friction loss.

ALLPAX consists of an intimate mixture of long, tough asbestos fibres, thin flakes of the highest grade of anti-friction metal, minute scales of graphite and a special non-liquid, heat proof lubricant. It is made in four coil sizes and is also furnished loose, both types being furnished in six styles for every type of stuffing box and for every fluid. Write for a trial order for your requirements—you will quickly discover its many advantages.

The Allpax Co., Inc., Mamaroneck, N. Y.

Distributors in principal cities

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THE PACKING THAT "PACKS ALL"

Reg. U. S. Pat. Off.

Centrifugal Pump Packing

Resilient Semi-Metallic

This exceptional packing consists of a resilient flax core over which is wound a heavy armor of many layers of babbitt foil.

The result is a packing which forms a resilient babbitted bearing as well as a perfect frictionless seal. Allows easy compression and resists vibration. Temperatures to 450° F.

Small samples and recommendations on request. Describe equipment.

John Crane

CRANE PACKING COMPANY
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To be sure of tight, leak-proof packing specify

DARCOID

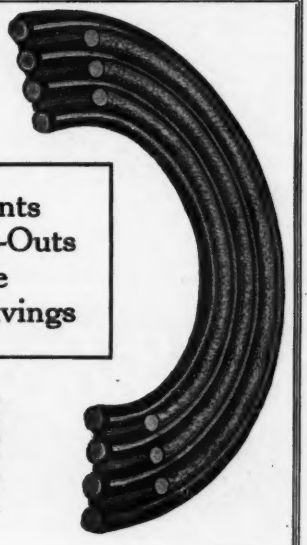
Here is the packing that gives long service and saves time, trouble and prevents leaky joints. Coated with graphite to prevent sticking—or natural to remain in a flange permanently.

THE DARCOID COMPANY, Inc.
P. O. Box 209, N. Y. City

Recommended for the smooth reciprocating rod or stem for nearly all kinds of service where the adjustable gland is used, such as steam pump rods and stems, air compressor rods, ice machines, steam engine rods and stems, rotary pumps handling water, oil, brine or chemicals. 5-lb. and 10-lb. cans. $1.50 per pound.

THE CONNEAUT PACKING CO.
Conneaut, Ohio

METALLO RESULTS



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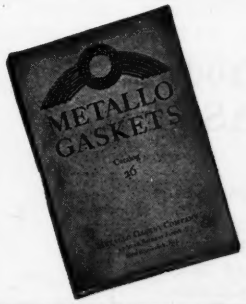
No Blow-Outs
Long Life
Large Savings

Try Metallo Gaskets and Discs to see the economies they will effect. Write for the large 32-page Metallo book, select items to try and we will send them for 90 days' free use.



METALLO
Gasket Company
New Brunswick, N. J.

GARLOCK

COMPLETE PACKING INFORMATION

An MA-1925 catalog, describing Garlock Mechanical Packing Service, should be in the hands of every person having supervision over any type of mechanical equipment.

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THE GARLOCK PACKING COMPANY
50 MAIN STREET
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The Standard Packing of the World

"*Flexitallic*" the *new* armor clad, self-centering gasket

Tested to 9000 lb. per square inch.

Write for information today!

Here is a gasket that will withstand the severest conditions—modern high pressures, high superheat, vibration, rough surfaces and acid. For boilers and pipe lines.

"Flexitallic" Gasket Co., Camden, N. J.
Without obligation to me, send folder giving data on Armor Clad "Flexitallic" Gasket.

Name .....
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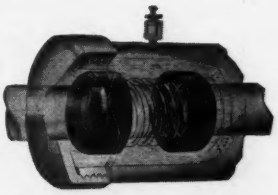
The way to stop leaks on all rotating shafts



COOKE SEAL RING

—insist on Cooke Seal Rings to do away with old-fashioned packing and to reduce operating costs

Troubles with packing on all machinery with rotating shafts such as compressors and centrifugal or rotary pumps handling ammonia, carbon dioxide, sulphur dioxide, brine, gasoline and other liquids or gases, are a constant source of trouble to the operator, besides lowering plant efficiency.

Engineers of today know the value of the Cooke Seal Ring. Manufacturers of all kinds of machines with rotary shafts, for power, refrigeration or refining plants, use Cooke Seal Rings as part of their regular equipment. Hundreds of plants install them!

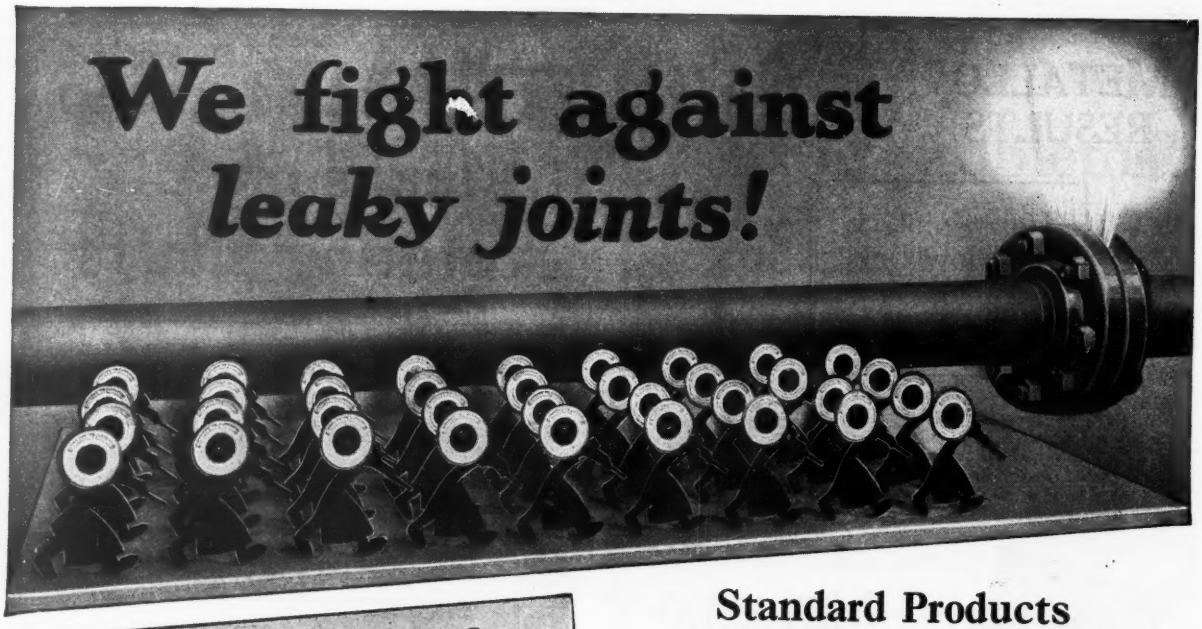
Because Cooke Seal Rings will eliminate leaks, packing, hot boxes, dirt, oil waste, scored shafts, motor overload and 85 per cent of packing friction!

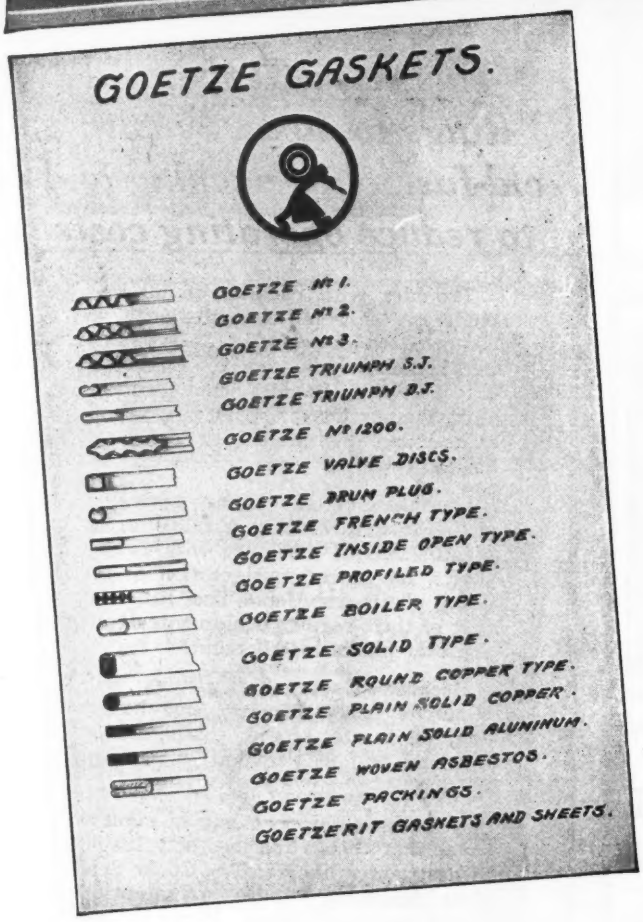
Investigate this well known money-saver that checks the loss of valuable or destructive liquids. The Cooke Seal Ring Assembly requires no attention except occasional oiling. Write for our booklet.

COOKE SEAL RING

Dept. L, 28 N. Green St., Chicago, Ill.

We fight against leaky joints!





Standard Products GOETZE GASKETS:

No. 1 Plain Corrugated Metal

No. 2 Corrugated Metal with Asbestos

No. 3 Corrugated Metal Asbestos with Graphite Cement

Triumph Type—Metal Shell—Asbestos
(a) Single Jacketed,
(b) Double Jacketed

French Type

Inside Open Type

Cylinder Head Gaskets

No. 1200 Type Metal Asbestos

Seamless Solid Rings

Washers for any purpose

Boiler Gaskets for Handholes, Manholes and Tube Caps

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Special Packings and Gaskets Stampings

Goetze Gasket & Packing Co., Inc.

17 Allen Ave., New Brunswick, N. J.

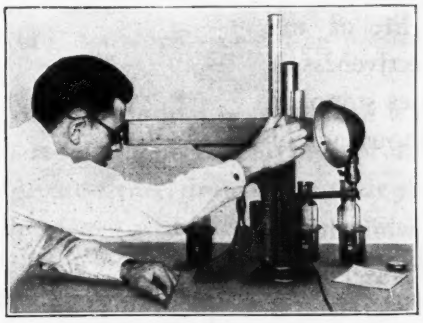
This Is No "Movie Star" Endorsement

October 23, 1929.

Dearborn Chemical Company.
Gentlemen:

"You recently asked me to give you my ideas regarding your Diesel Lubricating Oil—asking me such a question would be on a par with that of asking a parrot if he likes crackers. This will be all the more obvious if you will refer to your records wherein, I'm sure, you'll find I've been a regular user of various Dearborn products for about thirty years, and further, that I've bought from you in quantities varying from single gallons to carloads.

"Therefore, it would seem that if your oil had not worked better than the many others I have tried out, I'd have discontinued using it about twenty-nine years and eleven months ago.



Color Test (oil). Union Chronometer—National Petroleum Association

"During the thirty years of continuous use of your various oils, I have not had a single engine failure due to improper or inefficient lubrication, on any of our fleet of tow boats, which are equipped with various types of gas engines ranging in h.p. from 10 to 600, also on our sixteen Fairbanks, Morse full Diesels, which range from 50 to 560 h.p.

"On my latest tug which is powered with two 560 h. p. Fairbanks, Morse Diesel Engines, C. O. Type, I have used your Dearborn Medium Diesel Engine Oil, having now operated her 580 hours, most of which has been at top power, towing barges across

Pour and Cloud Test (oil). Method 20.11. A. S. T. M. Method D 97-22 T.

the twenty mile open channel. Have had perfect lubrication, although have not changed oil in the engine base, adding, of course, make-up to take care of losses, and direct lubrication to cylinder walls. The consumption averages slightly better than 1500 h.p. hours to each gallon lubricant consumed, which is about one third the consumption of a sister tug being operated here by another concern, on which, I understand, an asphalt lubricant is being used."

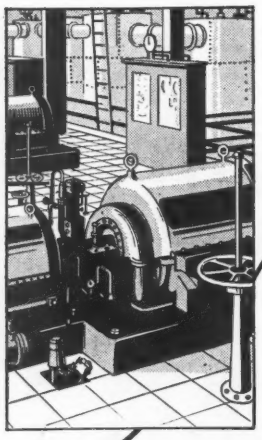
(Name on request)

* * * * * * * * *

On the strength of successes such as this, we confidently invite your inquiry regarding your lubrication problems, whether in Diesel, electric motor, worm gear, steam cylinder, heavy or light turbine and compressor services. Also greases for stoker and other equipment.

DEARBORN CHEMICAL COMPANY
310 South Michigan Avenue, Chicago
205 East 42nd Street, New York
Canadian Office and Factory
2454-2464 Dundas Street, West, Toronto

Dearborn
TRADE MARK REGISTERED
SCIENTIFIC LUBRICATION



No plant is modern without efficient lubrication

MODERNIZATION of plant equipment is the order of the day. Modern equipment, however, no matter how high its rated efficiency will not live up to expectations without proper lubrication.

Continuous production and the service life of any machinery is directly influenced by the effectiveness of its lubrication. Improper lubrication causes stoppage of production that yearly costs industry thousands of dollars.

It is not always a simple task to determine which lubricants are best for each particular type of equipment. Usually to be certain what oil or grease will give most efficient lubrication requires a practical technical knowledge of machinery and also a complete understanding of lubricants.

Lubrication Engineers of the Standard Oil Company (Indiana) have this knowledge. They have at their disposal a complete line of the highest quality lubricants that it is possible to make.

An engineer from our nearest branch office will be glad to study your lubrication requirements—at no cost to you.

Hear the Chicago Symphony Orchestra every Sunday at 2 p. m., Central Standard Time, over the following stations:

WGN	Chicago
WWJ	Detroit
WTMJ	Milwaukee
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For quick service use air mail

STANDARD OIL COMPANY (*Indiana*)

General Offices: 930 S. Michigan Ave. CHICAGO, ILLINOIS

Davenport	Duluth	Green Bay	Kansas City	Milwaukee	Quincy	St. Joseph
Decatur	Evansville	Huron	La Crosse	Minneapolis	Saginaw	St. Louis
Des Moines	Fargo	Indianapolis	Mankato	Minot	Sioux City	Wichita
Detroit	Grand Rapids	Joliet	Mason City	Peoria	South Bend	

1624

TIDE WATER INDUSTRIAL PLANT SURV NO. 9

LUBRICATING A *Reciprocating Type* STEAMSHIP

ON a test of a few days one marine engine oil may demonstrate the same efficiency and economy as another, but what a difference is shown when two oils are used in sister ships over a long period of time.

To insure the best results, Tide Water Lubricating Engineers study each problem with greatest care, drawing on their years of experience with similar problems to guide them in their recommendations.

They know when it is best to use a compounded or an uncompounded oil and what to recommend for main engine bearings, crosshead guides, crank pins, valve mechanisms, steam cylinder condenser pumps, refrigerating machinery.

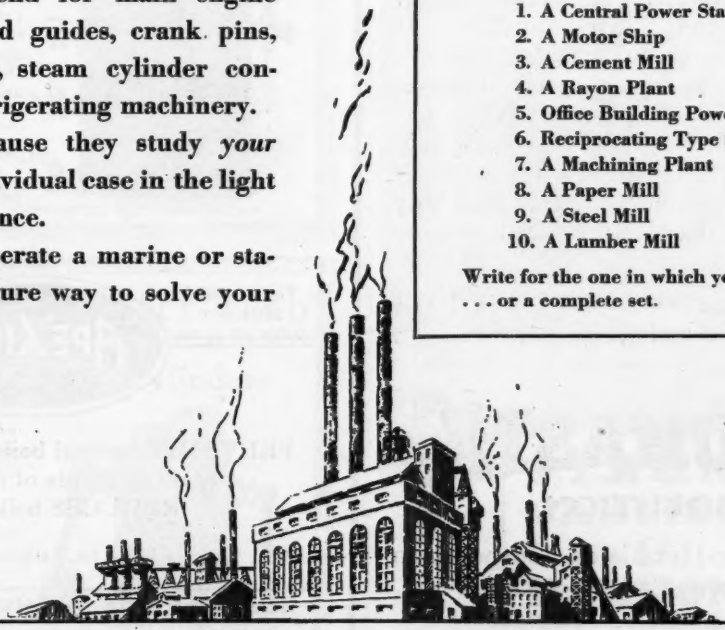
They know because they study *your* problem as an individual case in the light of years of experience.

Whether you operate a marine or stationary plant the sure way to solve your lubrication problem is to put it up to the Tide Water Engineer. He will be glad to survey your plant without charge. Tide Water Oil Sales Corporation, 11 Broadway, New York, N. Y.

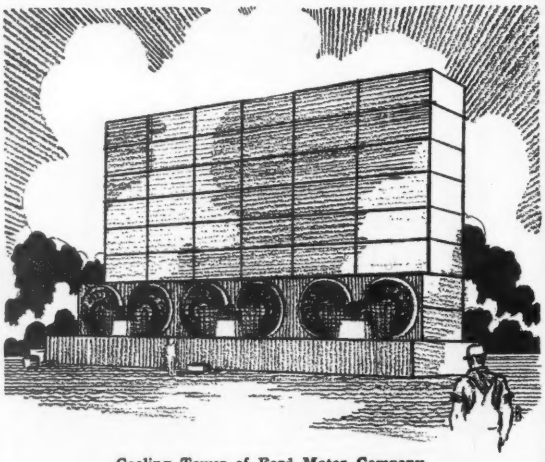
Tide Water Lubrication Bulletins now ready, include:

1. A Central Power Station
2. A Motor Ship
3. A Cement Mill
4. A Rayon Plant
5. Office Building Power Plant
6. Reciprocating Type Steamship
7. A Machining Plant
8. A Paper Mill
9. A Steel Mill
10. A Lumber Mill

Write for the one in which you are interested . . . or a complete set.



MADE BY THE MAKERS OF VEEDOL MOTOR OIL AND TYDOL GASOLINE



Cooling Tower of Ford Motor Company
Painted with *Bitumastic Solution*

Cover Them Well But Not So Often

Cooling towers represent a large class of steel structures which require adequate protection from corrosion but which are painted only with great difficulty. Their shapes and locations make it hard to paint them. To drain, dry, clean and paint them takes them out of service. These factors make the application of a LASTING paint of great importance.

Bitumastic Solution is ideal for painting cooling towers. It spreads easily, covers completely, dries quickly. It clings tenaciously to a clean surface, will not check, crack, peel, dissolve, emulsify, scale or blister. It is unaffected by oil, water, acids, alkalis, sun, cold or heat. Its glossy black finish remains bright much longer than any mere paint. Repainting need not be done so often.

Send for a trial order. Packed in 1 and 5 gal. pails, 30 and 50 gal. drums.

BITUMASTIC
REG. U.S. PAT. OFF.
SOLUTION

Wailes Dove-Hermiston Corporation
17 Battery Place, New York

Cleveland Houston San Francisco
Philadelphia Chicago Tulsa

DIXON GRAPHITE PRODUCTS

Lubrication Graphite Dixon

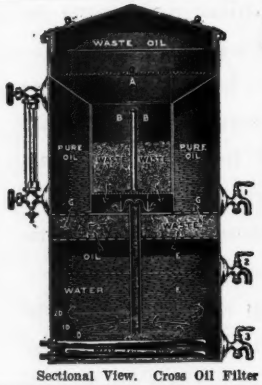
these three have been inseparably linked together in operating practice by mechanics, maintenance men, and engineers of the world's power plants for more than 100 years.

Flake Graphite — Belt Dressings
Boiler Graphite — Pipe Joint Compounds
Graphite Cup Grease — Motor Brushes
Waterproof Graphite Grease Silica-Graphite Paint

Write for Booklet 96-KP.

JOSEPH DIXON CRUCIBLE COMPANY
Jersey City New Jersey
Established 1827

The Keystone Lubricating Co.
Executive Office and Works: Philadelphia, Pa.



Sectional View. Cross Oil Filter

MAKE THIS TEST

Install a Burt Oil Filter in your engine room on a 30-day trial and keep an accurate record of the oil it saves. You'll find that you can reduce your oil bills from 50 to 75 per cent by using a Burt Filter.

The BURT MFG. CO.
Ventilators—Exhaust Heads
Oil Filters
44 E. South St., Akron, O.

The accepted protective **APEXIOR** REG. U.S. PAT. OFF. *boiler coating*

PREVENTS internal boiler corrosion
PROLONGS life of drums and tubes
REDUCES boiler maintenance costs

Write for Bulletin No. 1180

The DAMPNEY COMPANY of AMERICA
Hyde Park Boston, Mass.

Three of Chicago's largest theaters are using NUGENT

Tivoli Theater

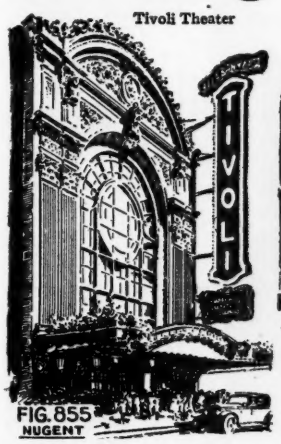


FIG. 855 NUGENT

Uptown Theater

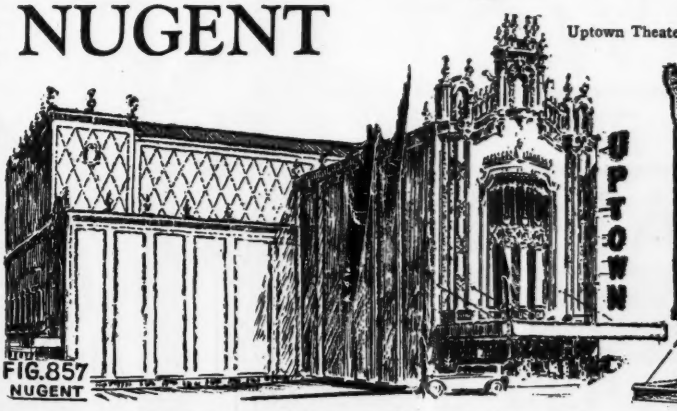


FIG. 857 NUGENT

Chicago Theater

FIG. 856 NUGENT

Nugent Oil Filters, Telescope Oilers and Complete Oiling and Filtering Systems are serving these large Balaban & Katz Theaters. In leading industrial and power plants, theaters, hotels and public buildings, engineers buy equipment only after a thorough investigation. Nugent is so often their choice because Nugent equipment can be relied upon for correct and sure service. Nugent Filters save 95% of the oil. Investigate the complete Nugent Line of Oiling Systems and Devices.

Established in 1897

WM. W. NUGENT & COMPANY
411 North Hermitage Ave., Chicago
Branches in Leading Power Centers

Builders of
Oil Filters, Oiling Systems, Continuous Oil Filtering Systems, Telescopic Oilers for Crosshead, Crank Pins and Eccentrics; Compression Pipe Fittings, Oil Pumps, Oiling Devices.

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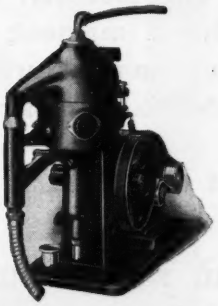
for Small Oil Engines

The
De Laval
Series "B"
Oil Clarifier

quickly saves its cost in reduced bearing wear and lowered oil bills. Write for details.



The De Laval Separator Company
New York Chicago San Francisco

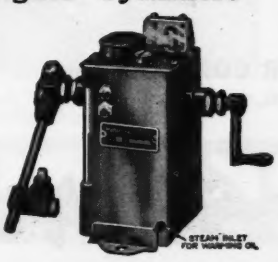
MANZEL FORCE FEED LUBRICATORS

Safeguard Engine Cylinders

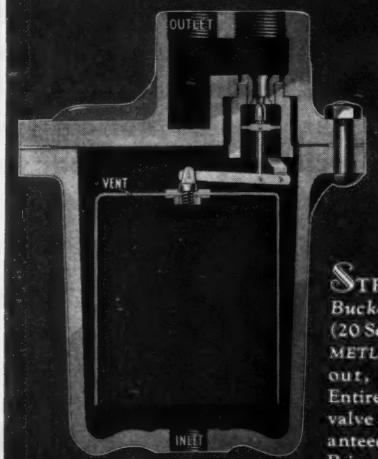
Manzel lubrication is positive. Increases the power and prolongs the life of machinery. Cuts oil bills 30 to 60%.

Made with one or more feeds, ratchet or rotary drive.

Write for Catalog No. 427



Manzel Brothers Co.
327 Babcock St.
Buffalo, N. Y.



STRONG *Inverted Bucket Steam Traps* (20 Series) are ANUMETL fitted throughout, as indicated. Entire trap as well as valve and seat is guaranteed for one year. Prices and specifications on request.

STRONG CARLISLE & HAMMOND

MANUFACTURERS OF STEAM SPECIALTIES • CLEVELAND, OHIO

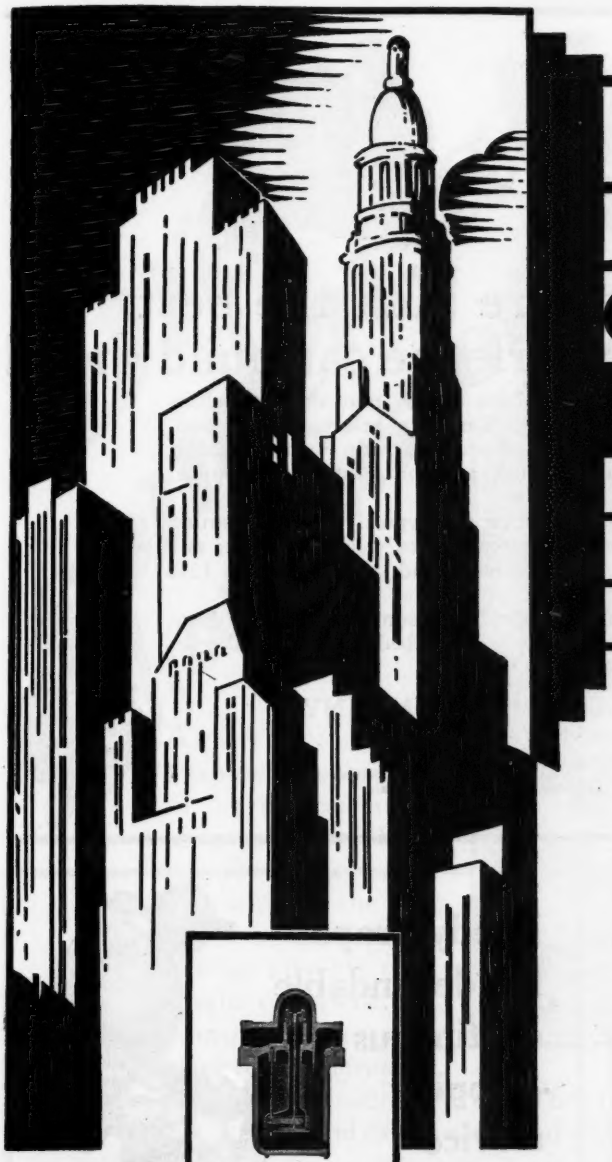
To Customers, Fellow Manufacturers and Other Friends

At this season of rejoicing and festivity, we are only too happy to pause for a moment in our appointed task of designing, manufacturing and selling the world's greatest line of control specialties, to wish our legion of customers, fellow manufacturers and our host of friends

A Most Merry Christmas and Prosperous New Year

FISHER

THE FISHER GOVERNOR COMPANY, Inc.
MARSHALLTOWN, IOWA



TOWERS OF CIVILIZATION

ARE DEPENDENT ON CORRECTLY BUILT MACHINERY

Wright-Austin equipment is correctly built, including the "Airxpel" Bucket Type Steam Traps, and the views below show the use of the "Airxpel" Trap in New York's great skyscraper, the Equitable Office Building, a building so large that it houses a city of 12,000 people.

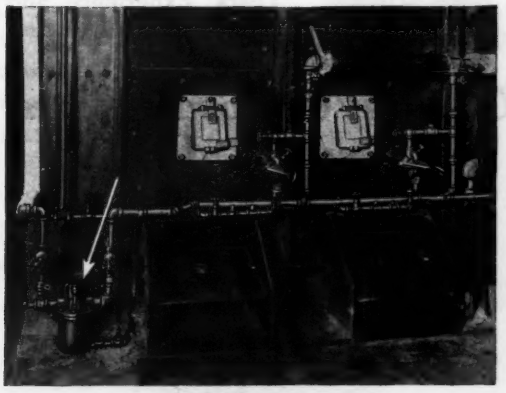
Buildings of this size and cost must have reliable equipment above all, and the selection of Wright-Austin traps is in keeping with this ideal.

The "Airxpel" Traps do not air bind. This feature and the great dependability of the "Airxpel" Traps make it possible to insulate them completely with pipe covering.

They are light and compact so that they hang on the pipe line, but they have unusually large capacity and are both simple and sturdy in construction.

Airxpel Steam Trap

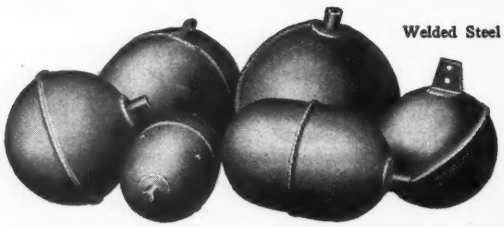
Airxpel Trap in Pump Room, Equitable Office Bldg., New York



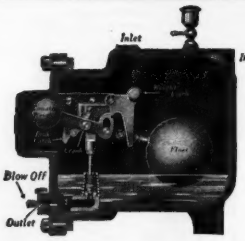
Airxpel Trap on Oil Burners, Equitable Office Bldg., New York

WRIGHT AUSTIN Co. DETROIT

315 W. WOODBRIDGE STREET

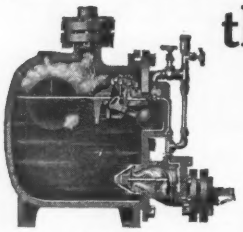


Welded Steel Floats



Nicholson Weight-Operated Trap

NICHOLSON Specialties are built the best that 41 years' experience can build them!



Nicholson Piston-Operated Super Trap

Specifications from the Nicholson Line means that the Specialties are guaranteed to give satisfaction. Carefully selected iron, steel, monel metal and bronze and skilled workmanship insure finished products that keep plant equipment safe and contribute to economical operation.

The Nicholson Floats shown above are typical of the attention given to parts. Made of two nickel steel halves welded together and nickel plated, they are guaranteed to withstand pressures up to 1350 lb.

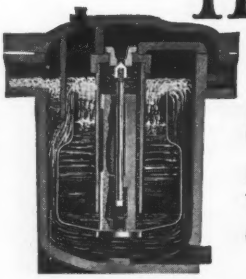
Write for full information about the Nicholson Traps, shown here, using these Floats. The entire line is described in our Catalogues for which there is no charge.

Nicholson Flexible Coupling

Nicholson Four-Way Control Valve

W. H. NICHOLSON & COMPANY
120 Oregon St., Wilkes-Barre, Pa.

Nicholson Expansion Steam Trap



ILLINOIS Eclipse STEAM TRAP

Backed by Over 35 Years' Experience and a Positive Guarantee.

Only TWO Moving Parts No Complicated Levers

The valve action is SNAP action. It is either tight closed or wide open. Never cracked on seat. Wire drawing impossible. Can't blow steam or air-bind.

Test one on your WORST service—Compare it with any other trap! We'll pay all transportation costs if it doesn't end your trap troubles.

Order one on 60-day free trial or write for Bulletin 34—Today.

Address: 21st Street and Racine Avenue

ILLINOIS ENGINEERING COMPANY
ROBT. L. GIFFORD, PRES. INCORPORATED 1900
BRANCHES AND REPRESENTATIVES IN 40 CITIES
CHICAGO

Bundy Traps for dependable continuous trapping service

Bundy Three-Valve Pumping Trap

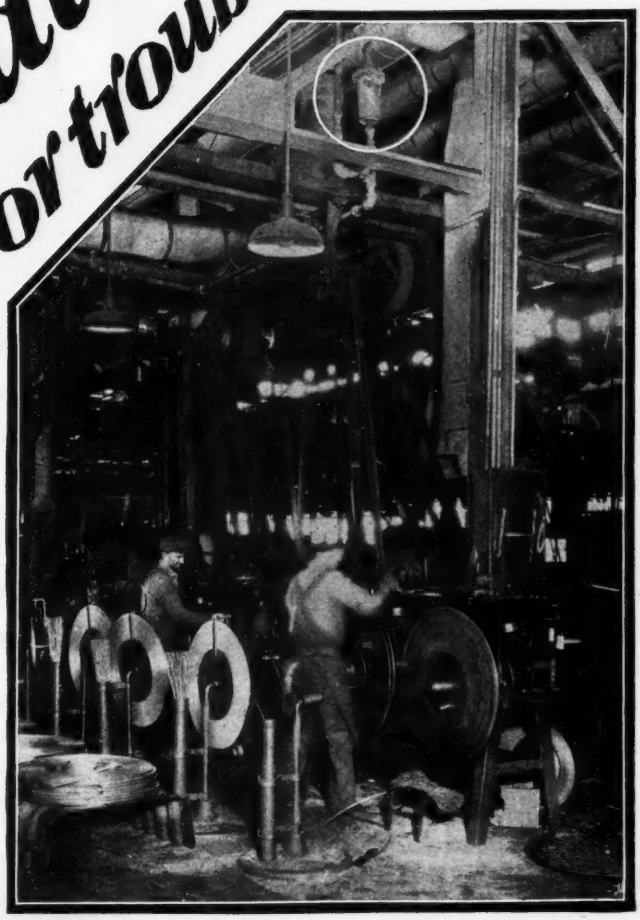
Here are the traps that keep steam systems and process equipment working at full capacity without trouble or attention, year after year. At a low investment savings are effected that materially lower operating costs. Bundy Boiler Return Traps often pay their total cost in a few months.

Write for information on the details of Bundy Traps. Investigate the advantages they are bringing to power and industrial plants of all kinds.

Consult us freely on your trapping problems.

Bundy Steam Trap Co.
39 Elm St., Nashua, N. H.
Engineering Representatives in principal power centers.

Drain condensate without fuss or trouble



ARMSTRONG Steam Traps will enable you to forget your trapping troubles. They remove the condensate without the loss of live steam, and discharge any air that would otherwise accumulate. You can place them in any convenient space—out of the way. They require no special support and can be easily and quickly installed.

Armstrong Trap draining main steam header in large steel fabrication plant. The installation is simple, compact and out of the way.

The unique construction of Armstrong Traps insures uninterrupted and efficient performance. They are made in types for all condensate draining problems up to 900 pounds pressure and 750° F temperature.

Armstrong Machine Works

310 Maple Street, Three Rivers, Michigan

District Representatives in 42 Cities

ARMSTRONG · INVERTED BUCKET · STEAM TRAP

Send coupon for free trial

ARMSTRONG MACHINE WORKS, **310** Maple St., Three Rivers, Mich.
Please ship prepaid an Armstrong Trap for a 90-day test. When the test is completed the trap will be returned collect.

For service on _____ *Steam Pressure (Maximum)* _____
Size of pipe _____
Name and Position _____
Firm _____
Street Address _____
City and State _____
Send Catalog ☐

PPE 12-15—Gray

Makes Valves and Instruments Give Better Service and Saves Cost of Cleaning

Automatic valves, traps, regulators, etc., can't perform efficiently when clogged with scale and sediment. Keep lines free of foreign matter with Sarco Strainers and you will get better service as well as save the cost of cleaning.

SARCO STRAINERS

can be quickly installed in any position on lines carrying steam, gas, water, oil, or any fluid. They do not restrict the flow. Blow-off connection permits cleaning instantly merely by opening valve.

Body is made of iron and the screen of brass or any other metal.

Write for Booklet B-100, or mail the convenient coupon.

SARCO CO., Inc.

183 Madison Ave., New York, N. Y.

Boston, Buffalo, Chicago, Cleveland, Detroit, Philadelphia, Pittsburgh, St. Louis

Sarco (Canada) Limited
1605 Delorimier Ave., Montreal

Sarco Co., Inc.,
183 Madison Ave., New York City.

Please send copy of Sarco Strainer Booklet B-100.

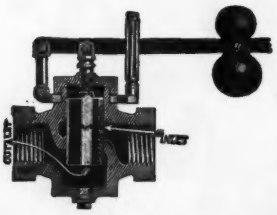
Name .....

Address .....

Town..... State.....

Watson Reducing Valve

With Lever and Weight



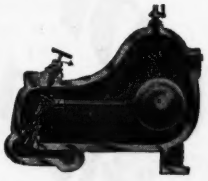
For Steam Only

This Valve is metal throughout all its parts, nothing complicated, one moving part only.

Should be used on all heating systems, kettles, water heaters, cooking utensils; in fact, wherever steam is to be reduced to 1 to 25 lbs. on the low pressure side.

McDaniel Improved Steam Trap

Adapted to use in Sugar Refineries, Candy Making, Laundries, Paper Mills, Heating Apparatus; in fact, any place where condensation collects and must be discharged without loss of steam.



WATSON & McDANIEL CO.
Manufacturers of Steam Saving Devices
448 N. Marshall St., PHILADELPHIA, PA.
Send for Complete Catalog

CONNOR Pumping Traps

incorporate PISTON-OPERATED Steam and Vent Valves. A study of their design and various engineering features will convince you of their outstanding superiority. Send for our 40 page Steam Trap Manual today.

THE W. B. CONNOR CO., Inc.
369 B Lexington Ave., New York

Manufacturers of non-return and pumping steam traps for all condensate requirements.

COCHRANE

Steam and Oil

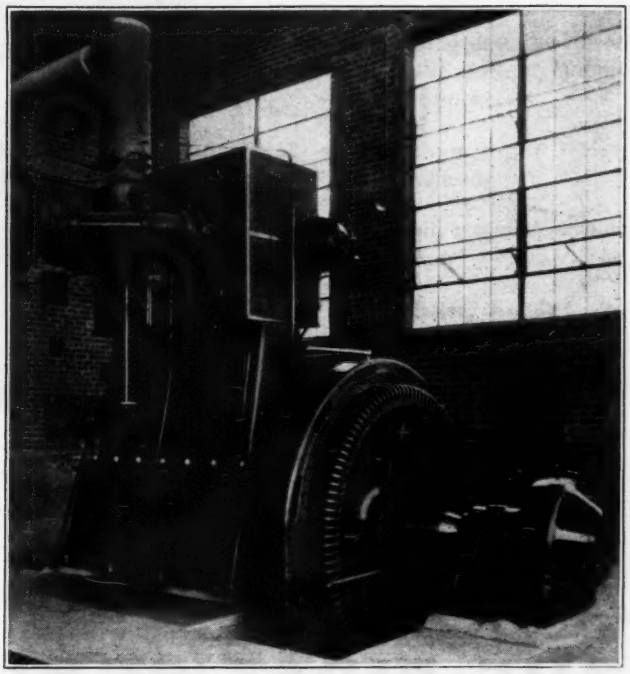
SEPARATORS

Cochrane Separators are made in all sizes and for vertical, horizontal and angle pipes. Cochrane Receiver Steam Separators store steam close to the throttle, equalizing the flow through the steam lines and raising the average pressure in the steam chest.

COCHRANE CORPORATION
3144 North 17th Street
PHILADELPHIA, PA. 360-2

Guarantees 99.5% dry on live steam

DIRECT SEPARATOR makes good wherever installed



Dry steam and clean steam! You can have both with Sweet's Direct Separators. Effecting great savings in repairs, oil and fuel, Sweet's come in standard sizes for all working pressures and capacities. For exceptional conditions, separators of special design are built.

More than 15,000 Direct Separators are installed in leading plants throughout the country. Installation shown here is in the Water and Light Plant at the City of Peru, Illinois.

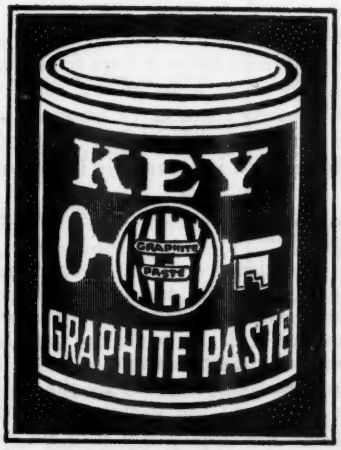
Investigate Direct Separators for your own plant. Our engineering department is available for consultation on your special requirements.

Write for Bulletin now

DIRECT SEPARATOR CO., Inc.
218 So. Geddes St., Syracuse, N. Y.

Spend a STAMP—

to Test This BETTER Joint Sealer



Daily new firms are ending joint leaks and the expense they entail—through the free test we here offer you. Key Graphite Paste is a greaseless, non-setting compound that seals perfectly all screw thread and gasket joints in lines carrying Oil, High Pressure Steam, Acid, etc. No petroleum product, no matter how thin, can penetrate it. Water only is required to thin it. It is as easy to use as any less effective compound, but seals 100% tight in every case. Under heat it expands, making the joint still tighter, yet allows it to be broken whenever necessary. Joints under vibration especially need Key Graphite Paste.

Key Graphite Paste is listed by the National Board of Fire Underwriters. Put it to test in your work. Mail the coupon for a liberal trial supply.

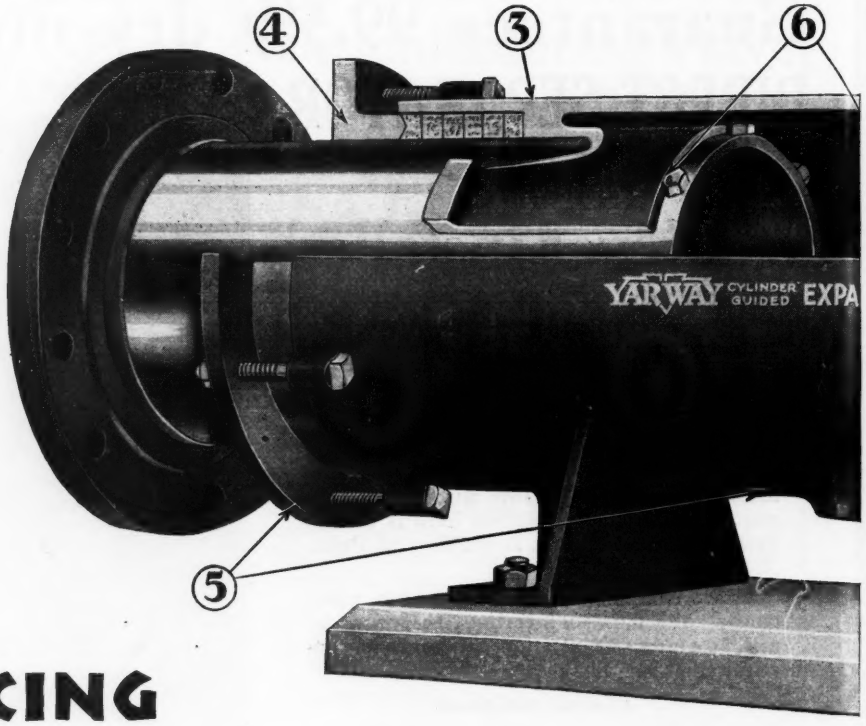
FREE TEST SUPPLY

KEY BOILER EQUIPMENT CO.,
East St. Louis, Ill. P. E. 12-15-29
Send me a free test supply of Key Graphite Paste.

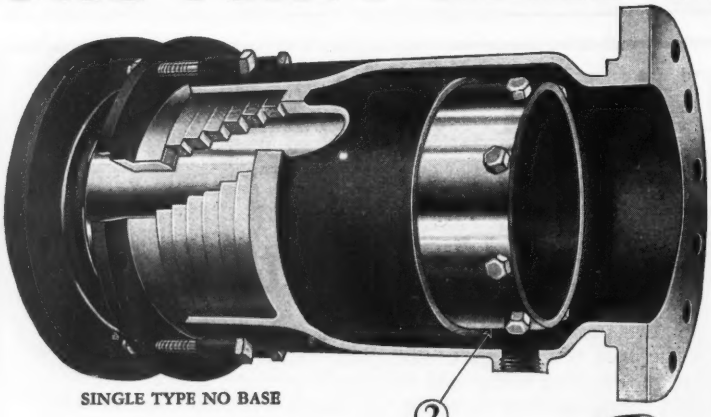
Company .....

Address .....

Requested by .....



ANNOUNCING THE FIRST REAL IMPROVEMENT



SINGLE TYPE NO BASE

SINGLE TYPE WITH BASE

ANOTHER important steam specialty has been added to the Yarway Line—the Yarway Cylinder-Guided Expansion Joint.

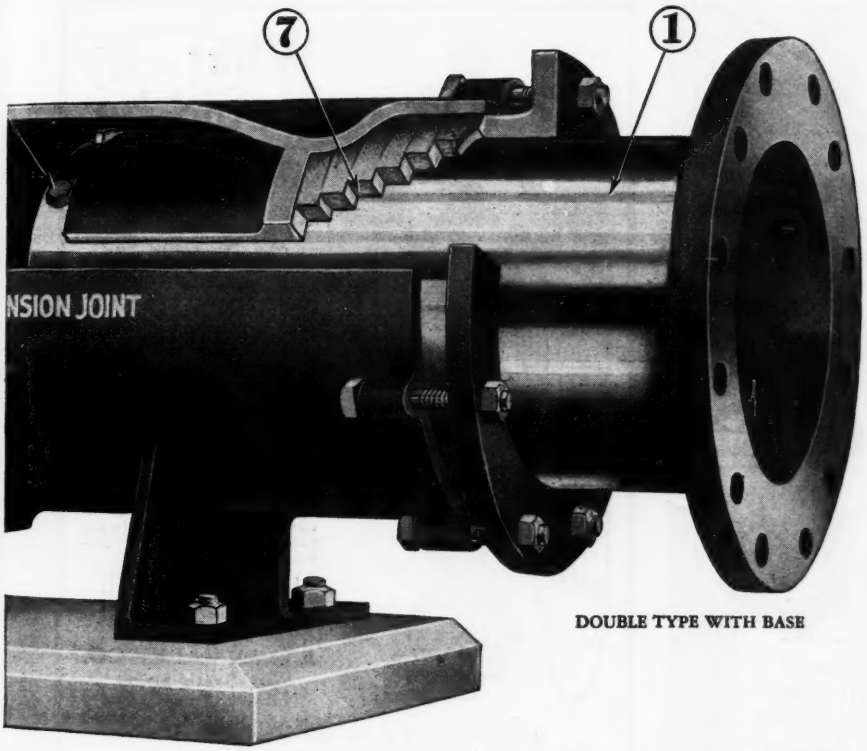
This joint is adaptable to practically every condition where expansion due to changes in temperature of high and low pressure steam mains, hot water and other liquid lines, exhaust lines from combustion engines, etc., must be met and overcome. The many features of construction which make it valuable for use in conduits, manholes, and inaccessible locations, are:—

1. *Cylinder-guided, chromium-covered steel sliding sleeve.*

The sleeve is made of extra heavy steel pipe, machined and chromium-covered to preserve the surface, to overcome sticking, and to slide through the packing gland with the least possible friction. It is held in positive alignment by the guide which is a part of the packing box body. The guide, being surrounded by the hot liquid, steam, or other vapor, expands equally with the sleeve, securing close clearance and freedom of movement.

2. *Sliding Sleeve away from inside bottom of body dirt pocket.*

This construction allows any foreign matter in the line, such as rust, scale, sand,



DOUBLE TYPE WITH BASE

1. Cylinder-guided, chromium-covered steel sliding sleeve.
2. Sliding Sleeve away from inside bottom of body dirt pocket.
3. Strong, light weight steel body.
4. Easily accessible packing gland.
5. Smaller diameter than pipe flange.
6. Substantial internal limit stops.
7. Large, deep stuffing box.

IN EXPANSION JOINTS FOR MANY YEARS

etc., to drop out of and away from the sleeve, overcoming cutting and resulting in longer life of the sleeve and the packing.

3. Strong, light weight steel body.

The body is made of the same material as the pipe line, and consequently has the same characteristics. Its light weight is a factor of economy in shipping and installation.

4. Easily accessible packing gland.

This feature, in a guided joint, has been warmly welcomed by engineers. The gland is placed in the most accessible position for adjustment and repacking. The gland bolts are placed so that when backed off they can be pushed back out of the way to leave unobstructed access for removing old packing and installing new.

5. Smaller diameter than pipe flange.

A valuable feature when working with underground pipe lines. Pipe tunnel or manhole can be made smaller with a large saving in excavation and concrete work.

THE YARWAY CYLINDER-GUIDED EXPANSION JOINT

6. Substantial Internal limit stops.

Provided for safety. Sleeve will not blow out in case a pipe line anchor gives way. Stops are of substantial construction.

7. Large, deep stuffing box.

Stuffing boxes are large and their depth is the same for all sizes.

Many installations have been made and the merits demonstrated in a variety of services.

Yarway Cylinder-Guided Expansion Joints are regularly made standard and extra heavy. All sizes furnished in double types with base, and in single types, both with and without base. The extra heavy type with its steel flanges is successfully used for superheated steam or other high temperature work. We shall be pleased to furnish prices, weights, and further information at your request.

YARNALL-WARING COMPANY
Mermaid Street Philadelphia

Don't hide your light under a bushel of coal dust

VACUUM clean it out! Your plant will be brighter—and that won't be all! . . . Machinery will be cleaner . . . will last longer. Workers will be healthier . . . do better work and more of it. Depreciation will slow down. And a dangerous fire hazard will no longer hang over your head.

Only vacuum cleaning can lick the coal dust problem. Sturtevant Vacuum Cleaners get every speck of it, no matter where it is. There's no getaway . . . nor comeback—for coal dust when a Sturtevant goes after it.

There are Sturtevant Vacuum Cleaners both Stationary and Portable . . . both Light and Heavy Duty. Ask our nearest office about the one best suited to your needs.

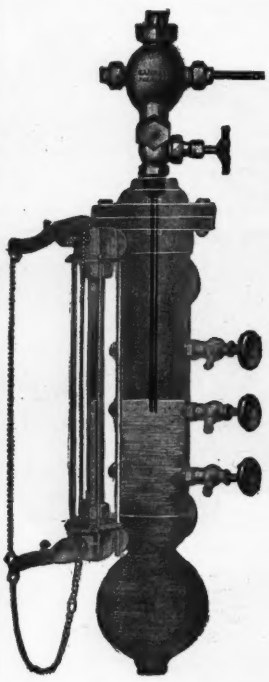
B. F. STURTEVANT COMPANY

Plants and Offices at: Berkeley, Cal., Camden, N. J., Framingham, Mass., Galt, Ontario, Hyde Park, Mass., Sturtevant, Wis. *Canadian Representative:* Kipp Kelley, Ltd., Winnipeg, *also Branches in Principal Cities and Agents in Foreign Countries.*

Sturtevant REG. U.S. PAT. OFF.

Portable and Stationary

Vacuum Cleaners



What could be simpler?

At the left we show the regulating element of the CAMPBELL Boiler Feed Water Regulator in place in a water column. No moving parts whatever . . . no floats . . . no thermostats . . . no links . . . no generators. The simplest and most dependable regulator obtainable. The

CAMPBELL Boiler Feed Water Regulator

costs less to install and maintain than any other. It is amazingly flexible. Holds the water level right where you want it all the time.

Get all the facts. We positively guarantee satisfaction. Write for bulletin.

ATLAS VALVE CO.
291 South Street
Newark, New Jersey

Regulating Valves for Every Service

On which do you want information?

- ☐ Campbell Boiler Feed Water Regulators
- ☐ Reducing Valves
- ☐ Damper Regulators
- ☐ Temperature Regulators
- ☐ Pump Governors
- ☐ Float Valves
- ☐ Swing Joint Fittings
- ☐ Bronze Unions
- ☐ Thermostats
- ☐ Balanced Valves
- ☐ Control Valves

EVERY RED CENT

THE body and actuating spring never wears out—a monel metal seat and chrome cone disc that are renewable and self-aligning make Reliance Gauge Cocks worth every red cent paid for them.

The one illustrated is for pressures up to 450 lbs. The Reliance High Pressure Gauge Cock is built for 1500 lbs. Send card for interesting folder.

THE RELIANCE GAUGE COLUMN COMPANY
5932 Carnegie Ave., Cleveland, O.

Reliance

The Safety Valve for High Pressures

Crosby Style HN Nozzle Pop Safety Valve for pressures up to 1500 lb., is tested and proven under most exacting conditions. Unusually large capacity. Meets all demands of modern central station operation. Write for information about the Crosby Line of Valves and Gages.

CROSBY STEAM GAGE & VALVE COMPANY
Boston, Mass., U. S. A.

R-K
TRADE MARK REG.U.S.PAT.OFFICE

4-WAY Solenoid Operated Valves

A Complete Line of Solenoid Valves for every purpose, including:

Solenoid Operated Shut-off Valves

Trip Valves

Pilot Valves

3-Way and 4-Way Valves

ALSO

Solenoid Operated Servo Motors

Send for Bulletin S. O. No. 2

R-K RUGGLES-KLINGEMANN MFG CO.

Philadelphia Office 517 Drexel Bldg. — MAIN OFFICE and WORKS R-K Building, Salem, Mass — Boston Office 38 Chauncy St. New York Office 39 Cortlandt St.

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Stop This Loss With Pickering Governors

Variance in paper weight and texture is caused by engine over- or under-speeding.

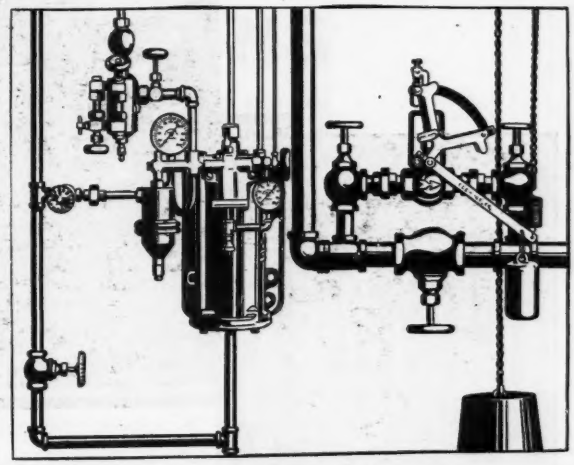
This loss of time and money is easily stopped if Pickering Governors control the engines.

For Pickering Governors assure dependable and accurate speed control. They predominate in paper mill service.

Write for free booklet 93M.

"Governor Builders Since 1862"

THE PICKERING GOVERNOR CO.
Portland, Conn.



A-JACKS CONTROL

Automatic, gradual regulation of breeching dampers to meet varying steam demands, synchronized to control valves or rheostats of stokers and blowers.

The A-JACKS Steam Damper Regulator is the most simple form of automatic combustion control it is possible to install.

The slightest changes in steam pressure cause instant response in the A-Jacks Regulator and immediate, gradual regulation of damper position and stoker or blower speed.

Power plant engineers all over the country testify to the advantages and economies of A-Jacks Control on boilers they have operated for years, because the A-Jacks regulator is extremely sensitive, requires very little attention, and is so designed that there is little or no wear on moving parts.

You incur no obligation in requesting descriptive literature.

NATIONAL

National Systems of Heat Regulation and Humidity Control, Metaphram Dampers, Metaphram Motors, Industrial Thermostatic Devices, A-Jacks Steam Damper Regulator for high pressure boilers, Metaphram Damper Regulators for domestic steam, vapor, vacuum and hot water heating boilers, Metaphram Furnace Regulators.

METAPHRAM

NATIONAL REGULATOR CO.
2300 Knox Avenue Chicago, Ill.

NATIONAL REGULATOR CO., 2300 Knox Ave., Chicago.
You may send me bulletin on A-Jacks Control.

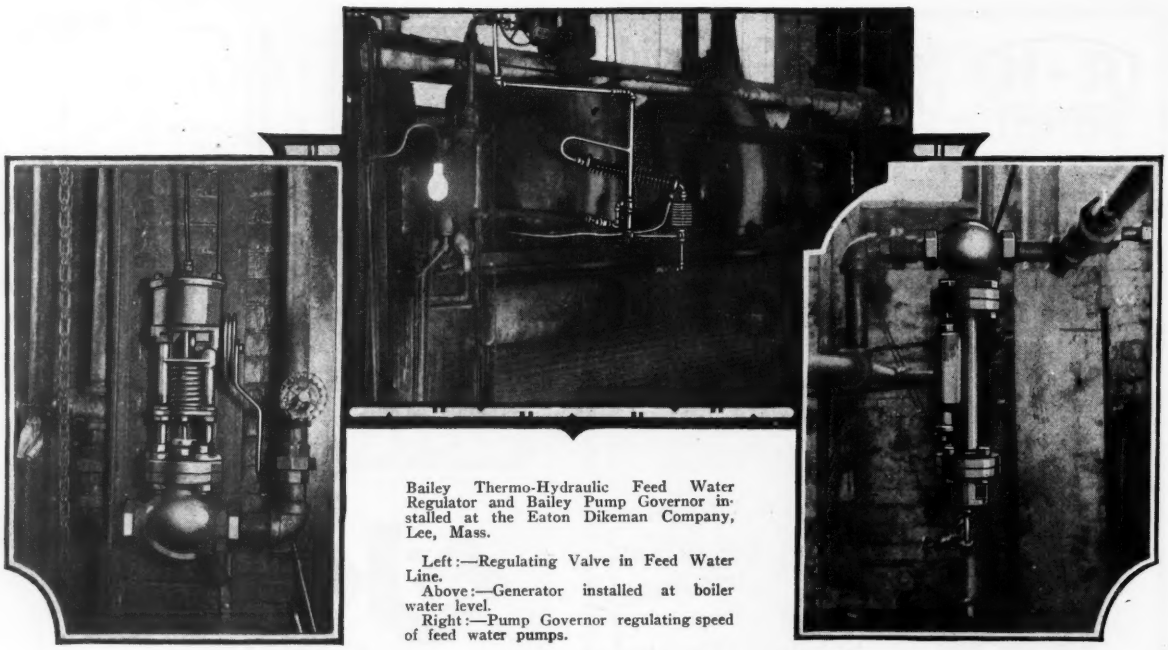
Name_____

Firm_____

Address_____

Town_____ **State**_____

No. of Boilers, Type and Pressure_____



Bailey Thermo-Hydraulic Feed Water Regulator and Bailey Pump Governor installed at the Eaton Dikeman Company, Lee, Mass.

Left:—Regulating Valve in Feed Water Line.
Above:—Generator installed at boiler water level.
Right:—Pump Governor regulating speed of feed water pumps.

Now They Have Effective Feed Water Regulation

Effective and Dependable feed water regulation is now being enjoyed by plant operators at the Eaton Dikeman Co., Lee, Mass. Since this Bailey Thermo-Hydraulic Feed Water Regulator and Bailey Pump Governor were installed the following results have been noted by Mr. Murdock, engineer at the Eaton Dikeman plant:

In spite of an extremely variable load the boiler water level is maintained at the correct level without any tendency to hunt whatsoever.

The regulator will absolutely hold the water level on a banked boiler over Sunday.

Steam pressure is more easily maintained since the Bailey Regulator has been installed.

Operation of feed water pumps was formerly rough and erratic—now it is smooth and steady.

Recently during a power failure this plant was without lights for two hours. During that time the Bailey Regulator was relied upon to maintain the water level. It did. When the lights came on the water level was correct.

The Eaton Dikeman Co. is only one of a fast increasing number of progressive companies which are turning to Bailey Regulating Equipment for feed water regulation which is both dependable and effective.

Distinctive Features

1. A fully balanced tight seating regulating valve with scientifically designed V-ports assures effective feed water regulation at all ratings.

2. Removable valve cage allows inspection or replacement of valve discs without removing valve from line.

3. Design makes possible use of hard bronze, monel metal, or stainless steel for valve discs.

4. Installation of generator is simplified by unit construction which requires only two connections to boiler drum or water column.

5. Leak-proof, all metal, hydraulic system with four-ply metal sylphon operates valve.

6. Relation of generator and sylphon volumes results in a safe hydraulic pressure under all conditions.

7. Steady action of the regulating valve is assured by a condensate by-pass in generator.

8. If emergency load causes high water level valve is closed instantaneously by safety seal in generator, and opened automatically as water level falls.

Write for Bulletin No. 82. It tells why Bailey Thermo-Hydraulic Feed Water Regulators give dependable and effective results.

BAILEY METER CO.

1040 IVANHOE RD. CLEVELAND, OHIO.

Bailey Meter Company Limited, Montreal, Quebec.

105 CENTRAL STATIONS USE 10 OR MORE COPES

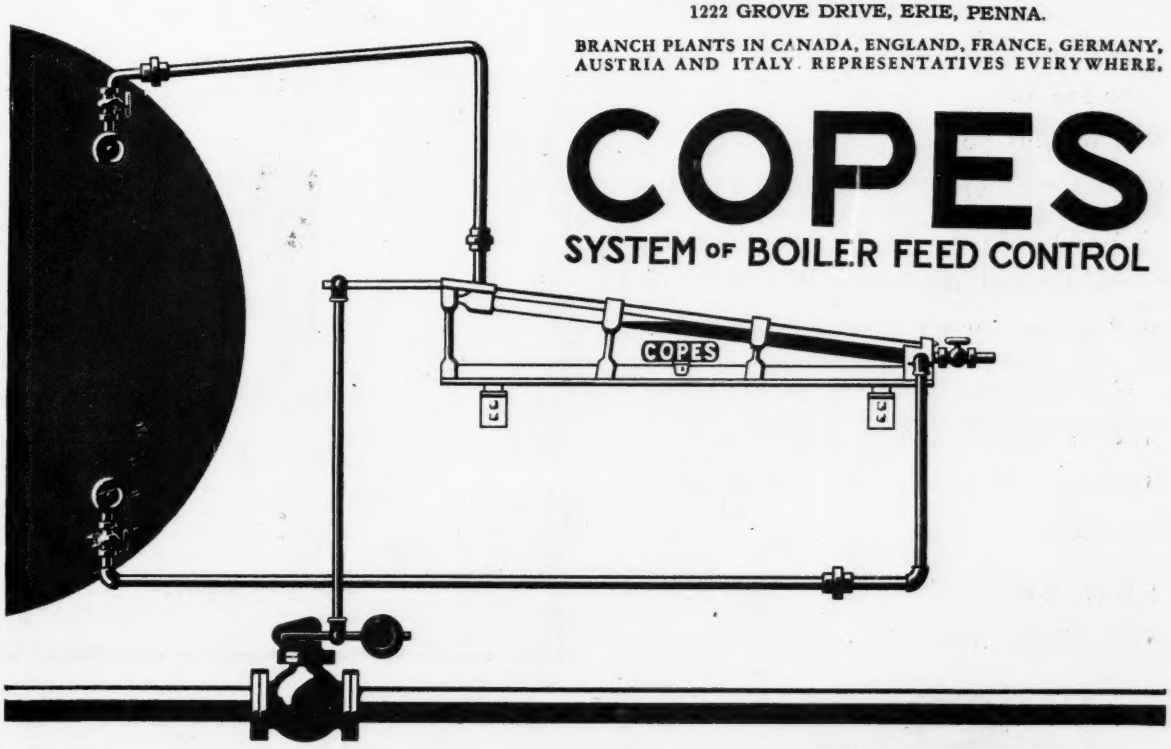
And 431 more have from 1 to 9 COPES Regulators at work for them. Surely, that is an enviable record of achievement in the public utility field.

Why this great preference? Simply because of added value. Equipment built exactly for the operating conditions. Instant, accurate response to changes in boiler load. Long life with little cost for maintenance and repairs. Plus the service of COPES engineers who make regular inspections of your equipment for years after its installation.

In your plant, COPES will give you more for the money invested than any other feed water regulating equipment. Write for the booklet — COPES Feed Water Regulators. It tells about *modern* regulation.

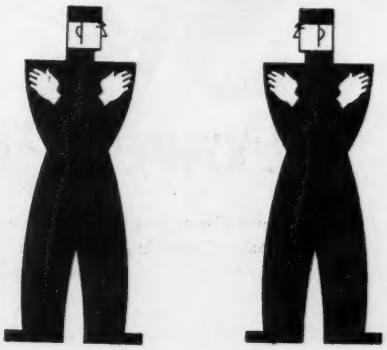
NORTHERN EQUIPMENT COMPANY
1222 GROVE DRIVE, ERIE, PENNA.

BRANCH PLANTS IN CANADA, ENGLAND, FRANCE, GERMANY, AUSTRIA AND ITALY. REPRESENTATIVES EVERYWHERE.



COPES

SYSTEM OF BOILER FEED CONTROL



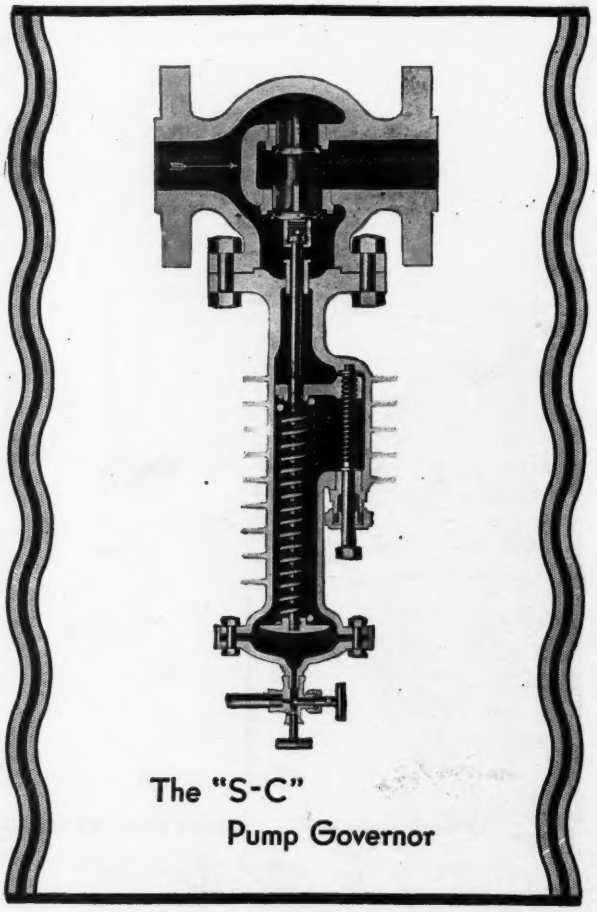
WHAT... no stuffing boxes?

SURPRISING as it may seem, here is a pump governor without a stuffing box . . . one in which friction parts have been eliminated to provide a super-sensitive control mechanism.

Chosen by the nation's largest power stations for use on pumps operating at from 600 to 750 pounds pressure, the "S-C" Pump Governor has demonstrated its ability, even where 725 degrees of steam must be passed through the valve. It is also widely used on pressures as low as 25 pounds.

Get the complete facts on the efficient "S-C" Pump Governor. Ask for a copy of Bulletin S-20-A which gives full description and data.

THE SWARTWOUT COMPANY
18511 Euclid Avenue *Cleveland, Ohio*

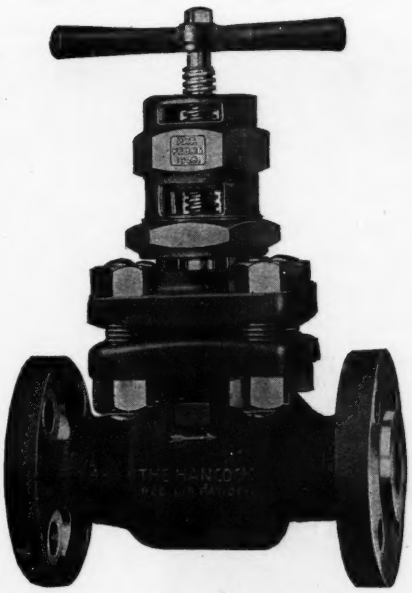


The "S-C" Pump Governor

Swartwout Power Plant Equipment

Feed Water Regulators . . . Pressure Valves . . . Pump Governors . . . Vacuum Governors . . . Master Controls . . . Reducing Valves . . . Relief Valves . . . Drainage Controls . . . Traps . . . Separators . . . Exhaust Heads . . . Feed Water Heaters

Superior Valve Service



The Hancock Valve is especially designed and constructed for high pressures and high temperatures, and for any service too severe for an ordinary valve. The Hancock is not a production valve. Each one is virtually hand-made to Hancock standards.

The Hancock Forged Steel Valve for pressures up to 1350 lbs. working steam pressure, and total temperatures to 900° F.

The Hancock Cast Steel Valve for pressures up to 600 lbs. working steam pressure, and total temperatures up to 750° F.

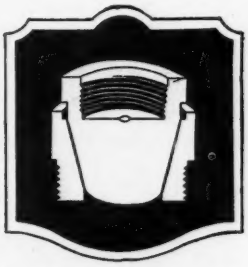
The Hancock Bronze Valve for pressures up to 300 lbs. working steam pressure, and total temperatures to 450° F., also Hydraulic types for 2000 lbs. and 100° F.

HANCOCK
GLOBE·ANGLE·CHECK
VALVES

The better performance of Hancock Valves compared with that of ordinary valves is of utmost importance to every engineer.

In this day of high power plant efficiency the engineer cannot afford to take chances with any valves which might develop leaky seats, wire-drawn discs, valve body distortion, defective packing boxes or other mechanical troubles. It's expensive, when you check up the time, labor and service interruption costs.

The basis of Hancock Valve superior service is better design, construction and workmanship. That results in fewer seat renewals and regrindings.



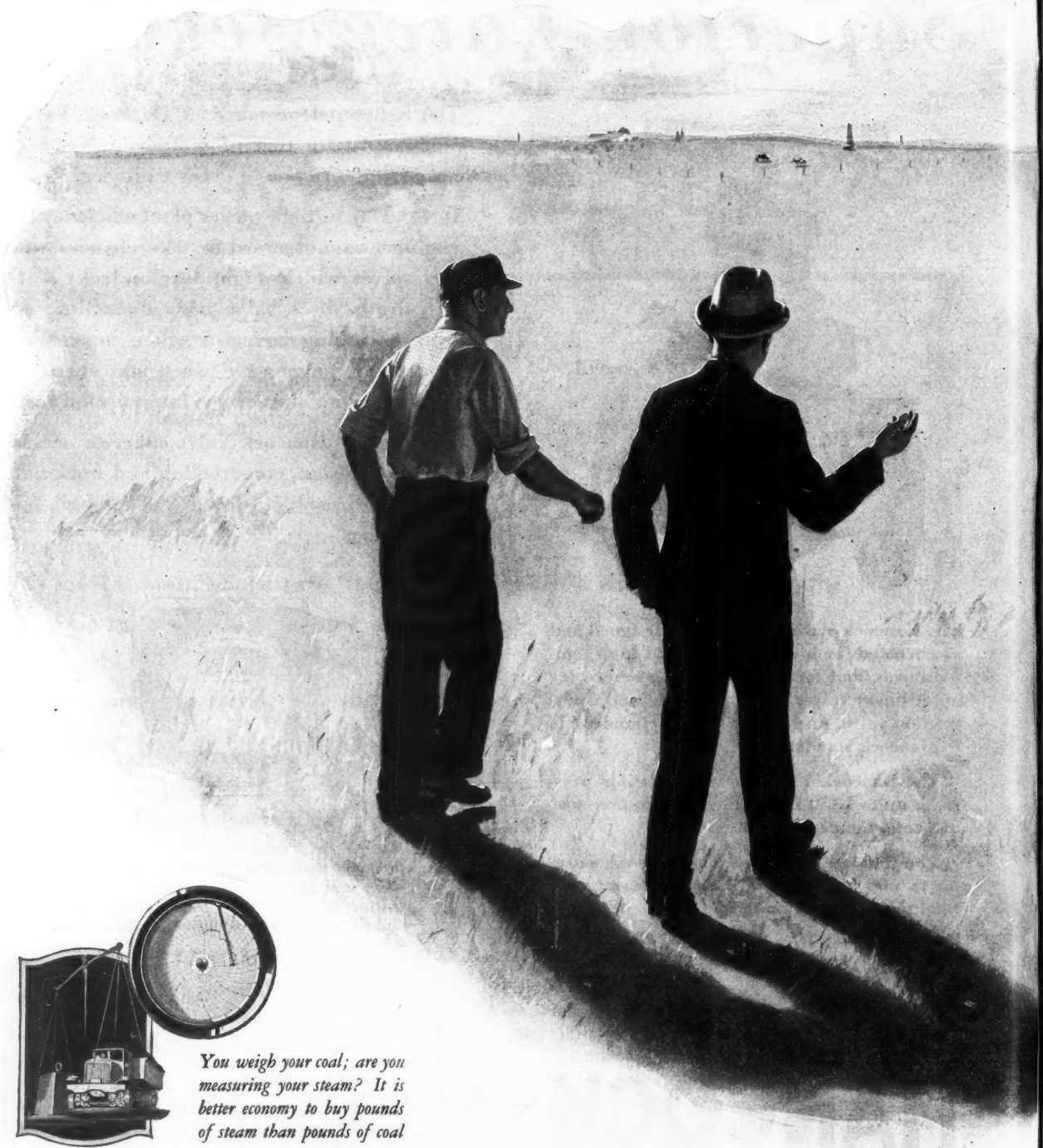
The Hancock Cone Seat

Every Cone is lapped into its own seat ring by hand until there is bearing contact over the entire cone seat surface. This insures a perfect fit over the wide ground seat area. It is typical Hancock precision workmanship.

Specify Catalogs Desired

Hancock Forged Steel Valves	W-34
Hancock Cast Steel Valves	WA-34
Ashcroft Power Control Valve	M-34
American Dial Thermometers	G-34
Consolidated Safety Valves	Z-34
American Recording Thermometers	H-34
American Temperature Controllers	R-34
Metropolitan Injectors	Y-34
American Relief Valves	V-34
American Glass Thermometers	F-34
Ashcroft Gauges	T-34
American Quality Gauges	A-34
American Recording Gauges	E-34
American Draft Gauges	B-34
American Gauge Testers	D-34
American Tachometers	J-34

CONSOLIDATED ASHCROFT HANCOCK COMPANY, INC.
Bridgeport, Conn.
Subsidiary of Manning, Maxwell & Moore, Inc.



You weigh your coal; are you measuring your steam? It is better economy to buy pounds of steam than pounds of coal

TURN THE WASTE OF TODAY INTO THE PROFITS OF TOMORROW

REPUBLIC INSTRUMENTS

The REPUBLIC

"It's a Half Mile Out There!"

Painted for Republic Flow Meters Co. by Geo. H. White

IT IS NOT UNUSUAL for a flow meter to pay for itself during the first few minutes of operation. Take, for example, this little incident which happened in the power plant of a well-known salt works.

A battery of fourteen steam flow meters had just been installed in the main distribution lines. Our service man was making his final check-up when the power superintendent happened to come along.

The superintendent stopped—looked at the meters and pointed to one, remarking, "You haven't set this meter yet, have you?"

"Yes, it is operating," replied our service man.

"I don't think it can be right—it's showing a flow of about 600 pounds per hour to a well that has been shut down for nearly two months."

"That is what your engineer told me, but I feel sure the meter is correct. How far is it out to that well?"

"It's a good half mile, but if you think the meter is correct, I'll hike out there with you and you can see for yourself."

In about an hour they returned. "That flow meter has paid for the entire installation already," remarked the superintendent. "How long that trap has been leaking or how long it would have continued to leak is hard to say, for we seldom have occasion to go out to a well that is shut down."

Republic Flow Meters can perform a similar service in your plant.

Bulletin "Steam Economy" mailed on request

REPUBLIC FLOW METERS COMPANY

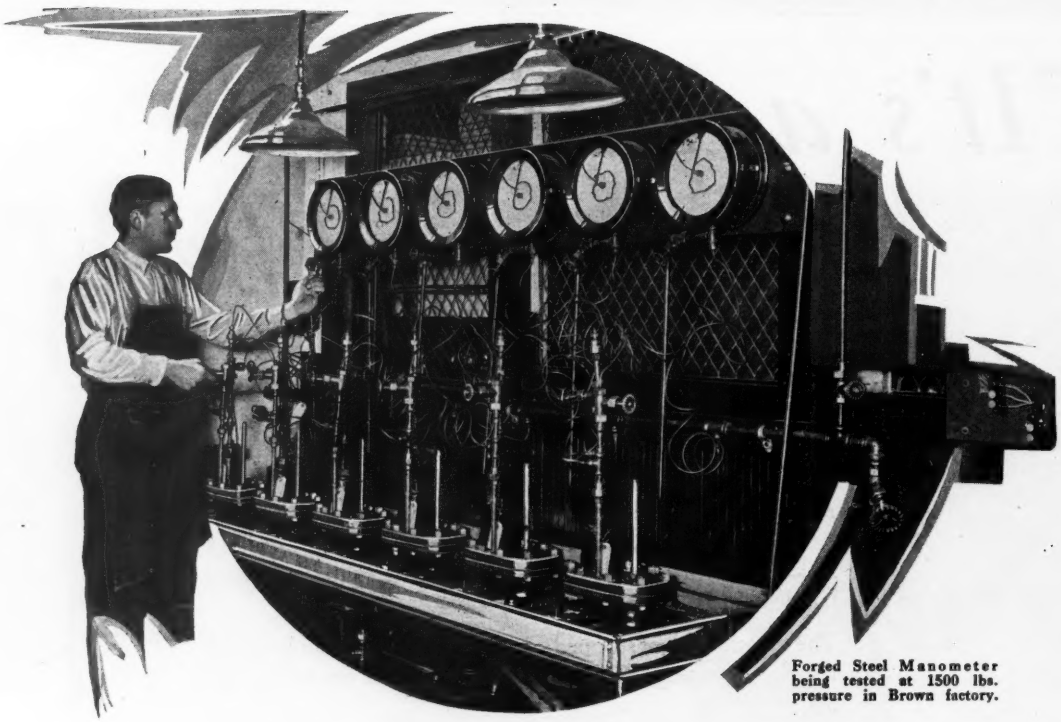
Executive Offices and Plant • **2224** Diversey Parkway • Chicago, Illinois

Branch Offices in 25 Principal Cities

DOMINION FLOW METERS CO., *Toronto, Canada* ELEKTROFLO, *Berlin, Germany* ELECTROFLO METERS CO., *London, England*

FLOW METERS

REPUBLIC INSTRUMENTS



Forged Steel Manometer being tested at 1500 lbs. pressure in Brown factory.

Forged
STEEL MANOMETERS

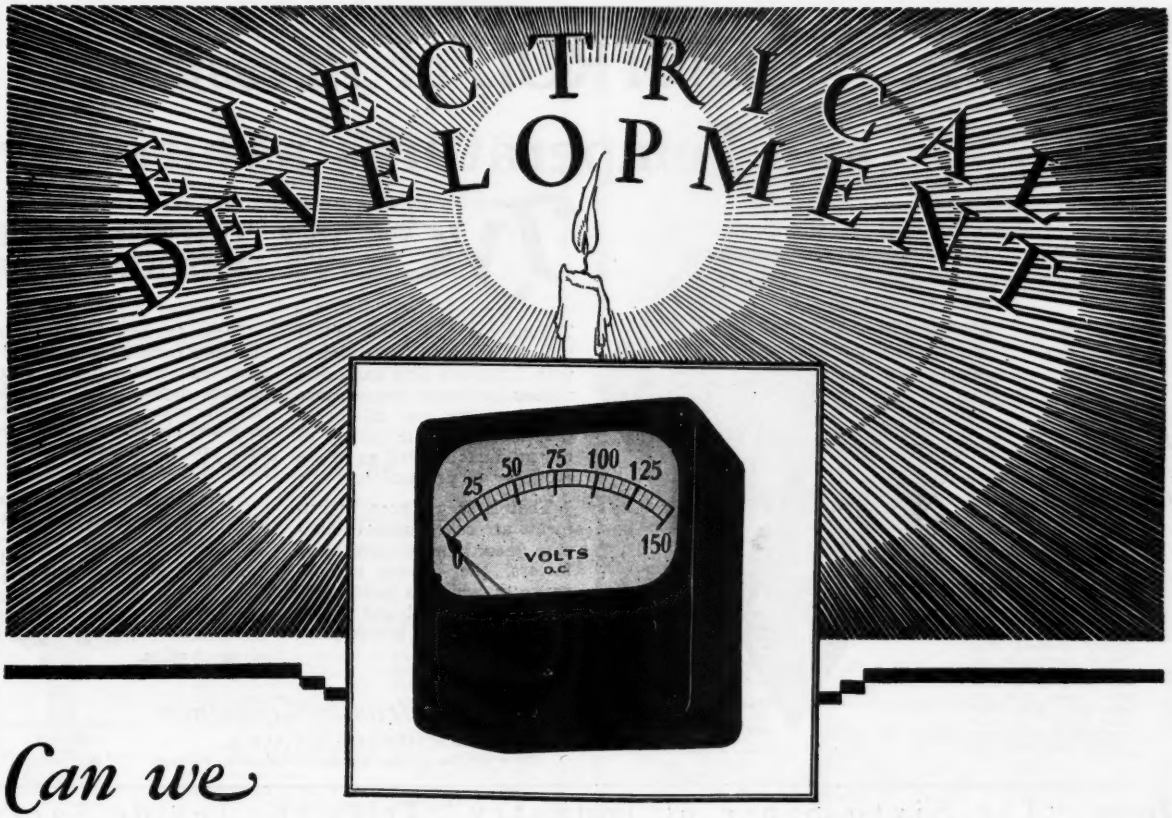
WITH high pressures becoming standard steam practice, a large safety factor in steam fittings becomes urgently necessary. In step with these advanced requirements come Brown Forged Steel High Pressure Manometers for use with Brown Electric Flow Meters. Hammer forged from bar stock. Individually tested to 1500 lb. pressure. Special high pressure models tested to 2500 lb. pressure. Brown Forged Steel Manometers are recommended for all pressures up to 750 lb.; special models for pressures up to 1500 lb. Supplied in standard ranges for high pressure service. Write for details—and Catalog No. 21.

THE BROWN INSTRUMENT COMPANY
4491 Wayne Ave., Philadelphia, Pa.
Branches in 20 principal cities.

"To measure is to economize"

Brown Electric Flow Meter

on the Inductance Bridge Principle



Can we throw some light on *your* problems?

NO single swallow makes a summer—nor does a single instrument go farther than a candle's feeble glow to lighten the problems of Electrical Development.

Take any Weston Instrument—any model or range. The most complete description possible would fail to convey a full conception of its probable uses. The needs of electrical measurement are too numerous and varied for any attempt at classification with respect to the application of a single instrument or, for that matter, Weston's complete line of instruments.

It is a case where the mountain should come to Mohammed! For more than forty years the Electrical Industry has come to Weston for the solution of its measurement problems. With the tremendous increase in scientific developments, involving the use of new instruments and special requirements as to design, electrical characteristics and ranges, it is becoming a problem in itself to sense the exact needs in all branches of industry.

But Weston research, manufacturing and consultation facilities are available to all. Engineering and sales representation in all the principal cities of the world affords convenient points of contact with instrument headquarters, so that your problems *can be brought to us* for study and solution. If the abridged listing in our catalog does not cover the instruments you require, we shall be glad to receive your communication and will give it prompt attention.

Weston
PIONEERS SINCE 1888
INSTRUMENTS

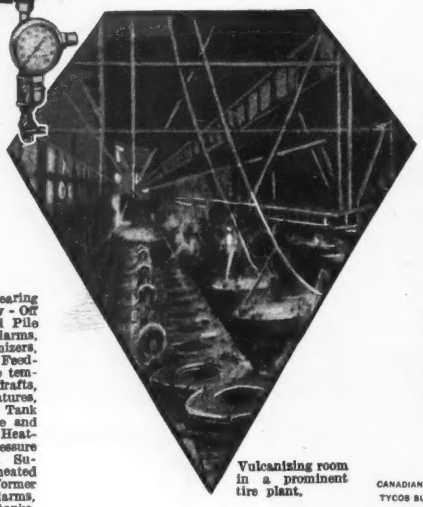
WESTON ELECTRICAL INSTRUMENT CORPORATION
599 Frelinghuysen Avenue - - - - - - - - Newark, N. J.

Tycos "Singl-Duty" Pressure Regulator. Also Temperature Regulators. All ranges required.

CONTROL of Pressures and Temperatures assured by Tycos TEMPERATURE INSTRUMENTS

Indicating
Recording
Controlling

on Air Ducts, Bearing Temperatures, Blow-Off Lines, Boilers, Coal Pile temperatures and alarms, Condensers, Economizers, Feedwater heaters, Feedwater lines, Furnace temperatures, Furnace drafts, Generator temperatures, Gravity overhead Tank Heaters, temperature and alarms, Hot Water Heaters, Hot Wells, Pressure lines, Steam lines, Superheaters, Superheated Steam mains, Transformer temperatures and alarms, Vacuum lines and tanks.



Vulcanizing room in a prominent tire plant.

Throughout the great industry of supplying the world with American tires and other rubber products, temperature and pressure are all-important factors in the quality of the products as well as in the economy of production.

That is why Tycos Instruments are called upon to indicate, record and control these factors, the correct maintenance of which is indispensable to economical and profitable operation in power plant and factory.

Tycos Control Instruments maintain conditions as predetermined with more than human dependability. Their rugged construction, sensitiveness and simple, scientific design are the outcome of 75 years' specialized experience.

At many critical points in power plants—small and large, industrial and public utility—Tycos Instruments save cost, improve operation and safeguard materials. Write for 64-page Tycos Book showing the complete line and points of application.

CANADIAN PLANT TYCOS BUILDING TORONTO

Taylor Instrument Companies
ROCHESTER, N.Y.U.S.A.
There's a *Tycos* or *Taylor* Instrument for Every Purpose

MANUFACTURING DISTRIBUTORS IN GREAT BRITAIN SHORT & MASON, LTD., LONDON

Tycos "The Sixth Sense of Industry" Tells the Inside Facts

C. J. Coal Meters *keep the eyes of operators on fuel savings!*

Cannot be tampered with. Constantly indicates coal burned under each boiler. Prompts boiler operators to do their best. Easily installed on underfeed stokers with revolving shaft. Free trial.

C. J. Mfg. Co.
3427 N. 5th St.
Philadelphia, Pa.

For all conditions of
Pressure and Vacuum

Recording Pressure Gauge

TRADE MARK
BRISTOL'S
REG. U. S. PAT. OFFICE.
Recording Instruments

Indispensable to efficient power plant operation are the records, indications and control of pressure, vacuum, temperature, mechanical motion, electricity, liquid level, etc., given accurately and dependably by Bristol's Instruments—a most complete line. Write.

The BRISTOL Company
Waterbury, Conn.

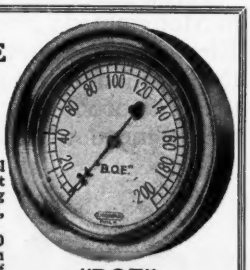
Rice Service— *for every type of plant*

Send for this free booklet!

From the smallest to the largest public utility or industrial plant, Rice Service for the scientific treatment of boiler feed water is available. At a low cost, thousands of users are protecting equipment and saving fuel.

Cyrus Wm. Rice & Company, Inc.
Water Chemists and Engineers
Highland Building Pittsburgh, Penna.

THE Lonergan LINE
for raising plant efficiency



"BOE" Gauge

Gauges for all purposes. Model "BOE" is guaranteed to meet the most exacting engineering specifications. First class design, workmanship and materials.

Model "QC" for 200 to 500 lb. pressure, can be closed from a distance by pulling chain if gauge glass breaks. Write for information on the full Lonergan Line—for safety and long service.

Model "QC" Water Gauge

J. E. LONERGAN CO.
Est. 1872 213 Race Street, Philadelphia, Pa.

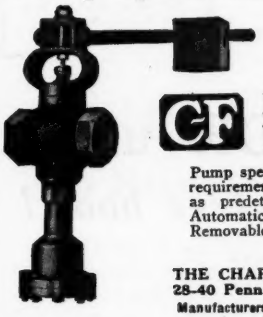
SIMPLEX
Boiler Feed Meters

SIMPLE—ACCURATE—DEPENDABLE

Write for data

SIMPLEX VALVE & METER COMPANY
6751 Upland St., Philadelphia, Pa.

Pump Speed and Excess Pressure



are both under absolute control when feed water to the boilers is regulated by the

CF Boiler Feed Pump Governor

Pump speed is always in accord with boiler requirements. Excess pressure is constant, as predetermined, and changed at will. Automatic operation. No complicated parts. Removable valve seats.

Write for circular.

THE CHAPLIN-FULTON MFG. COMPANY
28-40 Penn Ave. Pittsburgh, Pa.
Manufacturers of the Vigilant Feed Water Regulator and Other Steam Specialties

Get this
new booklet on how to prevent boiler troubles!

THIS attractive booklet explains "Magic" and how for ***Twenty-Five Years*** it has prevented scale, corrosion and pitting in boilers

Mailed on request

GARRATT-CALLAHAN CO.
San Francisco — Chicago — New York

MAGIC BOILER
"The FILM of PROTECTION for BOILERS"
PRESERVATIVE

BUILDERS IRON FOUNDRY
"Builders of the Venturi Since 1891"
15 CODDING ST. PROVIDENCE, R.I.

TYPE M VENTURI METER BULLETIN 190

TYPE Y VENTURI METER BULLETIN 233

VENTURI
"VENTURI" Registered

TYPE GK DIAPHRAGM METER BULLETIN 236

TYPE KS SHUNT METER BULLETIN 234

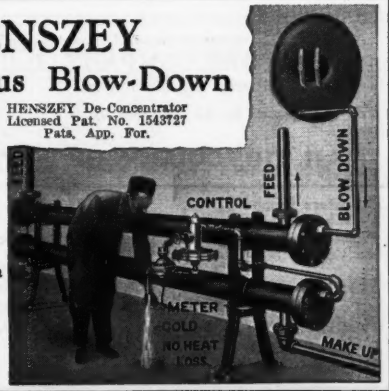
HENSZEY
Continuous Blow-Down

KEEP *your boilers in perfect condition.*

SAVE *the heat now wasted in your boiler blow-down*

HENSZEY De-Concentrator Company
Watertown, Wis.

HENSZEY De-Concentrator
Licensed Pat. No. 1543727
Pats. App. For.



An oil company saves oil with Hawk-Eye Compounds

The Name Is Your Protection

Accept No Substitutes

"We are saving about 10 barrels of fuel oil a day by using the Hawk-Eye Boiler Compound we purchased," wrote the Purchasing Agent of an oil refining company. Scarcely a water condition in the country that has not been successfully and economically treated in our 30 years' service. Write.

HAWK-EYE COMPOUND CO. (Not Inc.)
BLUE ISLAND, ILLINOIS

GAUGE GLASSES

High Pressure and Red Line High Pressure Glasses

Are guaranteed for pressure up to 400 lbs. for absolute uniformity of size and crystal clearness in service. They will stand the most radical and exacting tests that can be imposed on a gauge glass.

Specify American made by

The Libbey Glass Mfg. Co.
Toledo, Ohio

MADE IN AMERICA — LIBBEY GAUGE GLASS — WORTHY OF THE WORLD'S RESPECT

A Few Users

Standard Oil Co. (N. J.)
Tidewater Oil Co.
Texas Company
U. S. Shipping Board
Eastern Mass. St. Ry. Co.
Gas & Elect. Improvement Co.
International Nickel Co.
Whitehall Cement Mfg. Co.
Crocker-Wheeler Elect. Mfg. Co.
The Consolidated Fruit Jar Co.
Lidgerwood Mfg. Co.
Punta Allegre Sugar Co.
The Anglo Persian Oil Co.
Meux Brewery, London
Great Central Hotel, London
Wimbledon Power Station
Southern Railway
The Great Western Ry.
The French Navy
Etc., etc.

Review this list of FILTRATOR users

and send for free book!

The Non-Chemical way of keeping boilers and all kinds of equipment and systems free from scale, pitting and corrosion, Filtrators also overcome foaming, priming and caustic embrittlement. Filtrators cannot over treat the water.

Thousands of tons of fuel are saved yearly by FILTRATORS—boilers and other equipment are preserved, and time and labor saved. Why not send coupon for full information?

Giving complete satisfaction to the concerns listed above and to hundreds of others in this country and abroad, FILTRATORS surely are worth a thorough investigation.

The inexpensive* NON-CHEMICAL *Boiler Water Treatment

Water-Cooled Filtrator

FILTRATORS COMPANY, Inc.
96 Liberty St., New York
Agencies in All Principal Cities

MAIL THIS COUPON OR WRITE TODAY

Filtrators Company, Inc. P.P.E.12-29
96 Liberty St., New York City
Without obligation, please mail me your new booklet on "Reducing the Cost of Boiler Operation with Filtrators."

Name .....
Address .....
City .....State .....

How to guard against *Caustic Embrittlement*

WHILE the theory of caustic embrittlement is still being argued and lacks the acceptance of many engineers, it should be recognized that it has not been disproved. Wise engineers will therefore watch their boiler water carefully and keep it so conditioned as to avoid the possibility of embrittlement.

The first thing to do is to determine the total alkalinity-sodium sulphate ratio of the boiler water to see that it is on the safe side. If the proper ratio is not being maintained corrective measures should be taken immediately.

K.W.S. customers may either check the water themselves through either of two methods which we offer, or send samples of their boiler water direct to our laboratory for periodical examination. Both methods are based on the A.S.M.E. Code. "Rules for the Care of Power Boilers. Section VII, 1926." For higher pressures we use the tentative code which has not yet been adopted.

FREE OFFER
to Power Engineers

If you do not have the facilities for determining this ratio, send us prepaid a gallon sample of water taken from your boiler and we will tell you, free of charge, whether that sample meets A. S. M. E. requirements. We will also send you gratis our bulletin "Guarding against Caustic Embrittlement." Fill out and send us the coupon below. Be sure that your water sample bears your name and address. Also give all the information requested in the coupon.

K.W.S. SODIUM ALUMINATE

NATIONAL ALUMINATE CORPORATION CHICAGO

6224 W. 66th Place

Specialists in water softening, filtration, process work, waste water disposal, and all problems involving water supply and treatment. Manufacturers of National dry chemical feeders.

Representatives in Principal Cities

National Aluminate Corporation
6224 W. 66th Place, Chicago, Illinois

We are sending you prepaid one gallon of our boiler water in accordance with your free offer. Please tell us whether the ratio of this sample is on the safe side. Our boiler water is treated ☐ internally ☐ externally in a ☐ lime-soda softener ☐ zeolite softener. Our boiler horsepower is.....H.P. Pressure is.....

Name of Company.....

My name is.....

Address .....

City..... State.....

PPE-12-15-Gray

"It Opened Our Eyes"

"The Dean more than meets with our approval, and we assure you it opened our eyes in regard to the quantity of scale that may be on boilers, without one's knowing it."

—From a large Pennsylvania Steel Co.

* * *

"We find your Dean Boiler Tube Cleaner to be all that you claim for it. We extracted some four or five barrels of scale from four boilers we thought clean."

—From an executive of a large cotton mill.

* * *

"Our mistake was in not purchasing and using a Dean long ago, instead of depending on various 'compounds'."

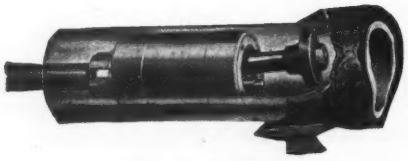
—Signed by the Engineer of a New York Hotel.

* * *

We'll gladly give you the names of the above concerns which would be recognized at once as leaders in their fields.

Dean in a Straight Tube

Dean in a Curved Tube



Dean in a Fire Tube

There is a Dean for every type and size of tube

SCALE *Will* FORM

THERE is no known method for economically preventing the formation of boiler scale while generating steam. Certain methods may reduce that formation, but when each

100 Pounds of Scale
Wastes 1¼ Tons of Coal a Week

Complete removal is essential, and no engineer will be satisfied by simply *reducing* such formation, and none will knowingly leave even as little as 50 pounds of heat-resisting scale on the tubes. You may not *believe* that you have scale on your tubes, but you can't be certain that they are clean until after you have used a DEAN BOILER TUBE CLEANER.

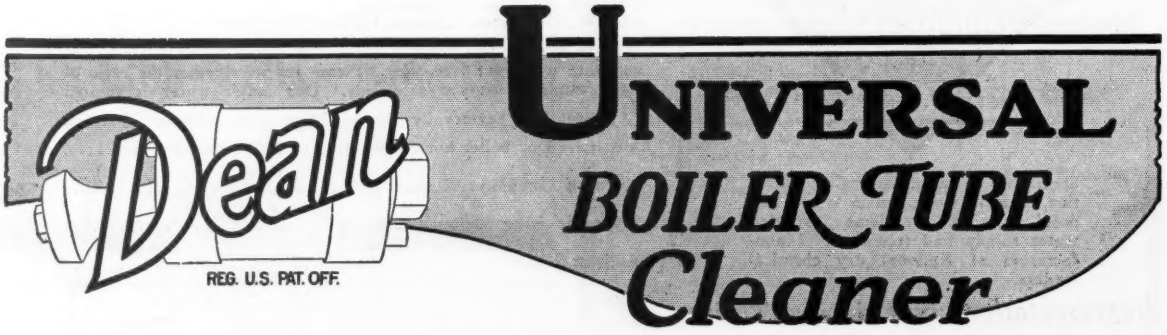
AND IT PAYS TO KNOW FOR CERTAIN

A Dean Cleaner on trial in your own plant will show you the *true* condition of your tubes — no guess-work, but an honest inspection and a real cleaning. You are offered a test of the Dean to prove the truth of the above statements.

NO CHARGE FOR A TRIAL

Tell us the style of boiler in which you'll make the test, and the size of tubes. We'll ship you a Dean for trial and if it doesn't sell itself by results produced, send it back at our expense at the end of thirty days and you'll owe us nothing.

THE WM. B. PIERCE COMPANY
149 Ellicott Street
Buffalo, N. Y.



Sparks from the Advertising Pages

Where Buyers and Sellers Meet

Hail to the New, Farewell to the Old

Glancing back over the past is a periodic necessity of every man. Custom through the ages has established the end of the old year and the beginning of the new as especially the time for taking "account of stock," whether of materials, funds, goods in stock, or of the unseen trends of business affairs.

In modern life all kinds of activities are checked to some extent much oftener than the traditional annual period. Power plants have continuous records which are frequently observed and filed at least once every 24 hours.

Once a day every man might well consider, for a moment at least, what he has accomplished in the day just past and what he is determined to accomplish during the coming day.

As day-by-day checks become more general in affairs of men, the annual review of the past becomes broader, more important and includes the discussion and decision on projects and policies for the year to come.

In recent years the speeding up of business and the rapid advances made in the power plant field in particular, have increased the usefulness of Power Plant Engineering's annual power plant review of progress.

No fluctuation in any field of business has recently occurred, or will occur for some time to come, that can appreciably affect the business of generating and distributing power, light and heat.

Nothing less than a recession to a lower order of being in homes, industries, transportation, sanitation, amusements, safety and communications can materially affect the power plant field.

Founded upon the solid rock of relieving labor, of adding time to each day's activity, and helping every other industry to lower costs and improve production, power is the very heartbeat of this nation.

Maintained on the basis of sound business and genuine effort to share savings effected between stockholders and customers, the field of power hails the new year as one of unlimited opportunity based on the farewell review of the achievements of the year now passing.

Machinery, Equipment and Supplies Used In The Production and Transmission of Power

Under the heading of each product listed will be found the names of the manufacturers of that product. The index to advertisers, next to the back cover, gives the page numbers on which the manufacturers' descriptive advertisements appear.

AIR COMPRESSORS
Allen & Billmyre Co., Inc., N. Y.
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Binks Mfg. Co., Chicago, Ill.
De Laval Steam Turbine Co., Trenton, N. J.
Gen. Elec. Co., Schenectady.
Ingersoll-Rand Co., New York,
Nash Engrg. Co., S. Norwalk.
Sullivan Machy. Co., Chicago.
Worthington Pump & Mach. Corp., New York.

AIR COOLERS
Griscom-Russell Co., New York.

AIR PREHEATERS
Air Preheater Corp., New York.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor,
Foster Wheeler Corp., N. Y.
Prat-Daniel Corp., New York.

AIR WASHERS
Badger & Sons Co., E. B., Boston

ALARMS, HIGH AND LOW WATER
Reliance Gauge Column Co., Cleveland.
Wright-Austin Co., Detroit.
Yarnall-Waring Co., Phila.

ANTI-CORROSIVE COATINGS
Dampney Co. of Am., Boston.

ARCHES, BOILER AND COMBUSTION
Detrick Co., M. H., Chicago.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.

ASH BIN GATES AND DOORS
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.

ASH HANDLING SYSTEMS
Allen-Sherman-Hoff Co., Phila.
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila.
Combustion Engrg. Corp., N. Y.
Detrick Co., M. H., Chicago.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

BAROMETERS
Taylor Inst. Co., Rochester.

BEARINGS
National Tube Co., Pittsburgh.

BELT CONVEYORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Fairfield Engrg. Co., Marion, O.
Jeffrey Mfg. Co., Columbus.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

BELT DRESSING
Dixon Crucible Co., Jos., Jersey City, N. J.
Standard Oil Co. (Indiana), Chicago, Ill.

BELTING, SILENT CHAIN
Morse Chain Co., Ithaca, N. Y.

BLOWERS, FAN & FURNACE
Air Preheater Corp., New York.
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Ingersoll-Rand Co., New York,
Prat-Daniel Corp., New York.
Wing Mfg. Co., L. J., New York.

BLOWERS, FORCED DRAFT
Sturtevant Co. B. F., Boston.
Wing Mfg. Co., L. J., New York.

BLOWERS, PORTABLE
Allen & Billmyre Co., Inc., N. Y.
Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

BLOWERS, PRESSURE
Carling Turbine Blower Co., Worcester, Mass.
Wing Mfg. Co., L. J., New York.

BLOWERS, PULVERIZED COAL
Wing Mfg. Co., L. J., New York.

BLOWERS, STEAM
Schutte & Koerting Co., Phila.

BLOWERS, TUBE
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
Vulcan Soot Cleaner Co., Dubois, Pa.

BLOWERS, TURBINE
Allen & Billmyre Co., Inc., N. Y.
Carling Turbine Blower Co., Worcester, Mass.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Wing Mfg. Co., L. J., New York.

BOILER BAFFLE CONTRACTORS
Boiler Engrg. Co., Newark, N. J.

BOILER BAFFLES
Boiler Engrg. Co., Newark, N. J.
McLeod & Henry Co., Troy, N. Y.
Quigley Furnace Spec. Co., N. Y.
Refractory & Engineering Corp., New York.

BOILER BLOW-DOWN SYSTEMS
Henszey De-Concentrator Co., Watertown, Wis.

BOILER CAP CLEANERS
Lagonda Mfg. Co., Springfield, O.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 166

BOILER COATINGS
Dampney Co. of Am., Boston.

BOILER COMPOUND
Dearborn Chemical Co., Chicago.
Garratt-Callahan Co., Chicago.
Hawk-Eye Compound Co., Blue Island, Ill.
McLeod & Henry Co., Troy, N. Y.

BOILER ENGINEERS
Boiler Engrg. Co., Newark, N. J.

BOILER FEED WATER, PURIFYING APPARATUS
Griscom-Russell Co., New York.

BOILER FRONTS
McClave-Brooks Co., Scranton,
McLeod & Henry Co., Troy, N. Y.

BOILER SETTING CEMENT
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Lavino and Co., E. J., Phila.,
Refractory & Eng'r'g Corp., N. Y.

BOILER SETTINGS
Ballard, Sprague & Co., Inc., New York, N. Y.
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.
Refractory & Eng'r'g Corp., N. Y.
Rust Engrg. Co., Pittsburgh.

BOILER TUBE CAPS
Key Boiler Equipment Co., E. St. Louis, Ill.

BOILER TUBE CLEANERS
General Specialty Co., Buffalo.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

BOILER TUBES
Bethlehem Steel Co., Bethlehem, Pa.
Boiler Tube Co. of America, Pittsburgh, Pa.
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.

BOILERS
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Combustion Engrg. Corp., N. Y.
Connelly Boiler Co., The D., Cleveland, O.
Edge Moor Iron Co., Edge Moor,
Erie City Iron Works, Erie, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works, Burlington, Iowa.
Nuway Boiler & Engrg. Co., Chicago, Ill.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Union Iron Wks., Erie, Pa.
Vogt Mach. Co., Henry, Louisville.
Wickes Boiler Co., Saginaw.

BOILERS, HEATING
Edge Moor Iron Co., Edge Moor.
Titusville Iron Works Co., Titusville, Pa.

BOILERS, RETURN TUBULAR
Erie City Iron Works, Erie, Pa.
Murray Iron Works, Burlington, Iowa.

BOILERS, SEMI-PORTABLE
Erie City Iron Works, Erie, Pa.

BOILERS, WASTE HEAT
Babcock & Wilcox Co., The, N.Y.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Wickes Boiler Co., Saginaw.

BOILERS, WATER TUBE
Babcock & Wilcox Co., The, N.Y.
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor.
Erie City Iron Works, Erie, Pa.
Murray Iron Works, Burlington, Iowa.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Wickes Boiler Co., Saginaw.

BREECHINGS
Connery & Co., Inc., Phila.
Littleford Bros., Cincinnati, O.
Prat-Daniel Corp., New York.

BRICKS, FURNACE LINING
Norton Co., Worcester, Mass.

BRUSHES, DYNAMO AND MOTOR
Dixon Crucible Co., Jos., Jersey City, N. J.

BRUSHES, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

BUCKET ELEVATORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Fairfield Engrg. Co., Marion, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

BUCKETS, CLAMSHELL
Orton Crane & Shovel Co., Chicago, Ill.

BUCKETS, COAL HANDLING
Jeffrey Mfg. Co., Columbus, O.
Orton Crane & Shovel Co., Chicago, Ill.

CAR DUMPERS
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CARRIERS, PIVOTED BUCKET
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Jeffrey Mfg. Co., Columbus, O.
Stephens - Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

CASTINGS
Fuller Lehigh Co., Fullerton, Pa.
Neemes Fdry., Inc., Troy, N. Y.

CEMENT, ACID-PROOF
Quigley Furnace Spec. Co., N. Y.

CEMENT, FURNACE
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh.
Johns-Manville Corp., New York.
Lavino and Co., E. J., Phila.,
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Refractory & Eng'r'g Corp., N. Y.

CEMENT GUNS
Cement-Gun Co., Inc., Allentown, Pa.

CEMENT, HIGH TEMPERATURE
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh, Pa.
Johns-Manville Corp., New York.
Lavino and Co., E. J., Phila.,
McLeod & Henry Co., Troy, N. Y.
Norton Co., Worcester, Mass.
Quigley Furnace Spec. Co., N. Y.
Refractory & Eng'r'g Corp., N. Y.

CEMENT, IRON
Smooth-On Mfg. Co., Jersey City

CEMENT, REFRACTORY
Quigley Furnace Spec. Co., N. Y.
Refractory & Engineering Corp., New York.

CHAIN WHEELS
Babbitt Steam Specialty Co., New Bedford, Mass.

CHAINS, DRIVE
Link-Belt Company, Chicago.
Morse Chain Co., Ithaca, N. Y.

CHEMICALS, WATER TREATING
National Aluminate Corp., Chicago, Ill.

CHIMNEYS
American Chimney Corp., N. Y.
Ballard, Sprague & Co., N. Y.
Littleford Bros., Cincinnati,
Prat-Daniel Corp., New York.
Rust Engrg. Co., Pittsburgh.
Springfield Boiler Co., Springfield, Ill.

CIRCUIT BREAKERS
I-T-E Circuit Breaker Co., Philadelphia, Pa.

CLEANING COMPOUND
Dearborn Chem. Co., Chicago.

COAL AND ASH-HANDLING MACHINERY
Allen-Sherman-Hoff Co., Phila.
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila.
Detrick Co., M. H., Chicago.
Fairbanks, Morse & Co., Chicago.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago.
Orton Crane & Shovel Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

COAL BUNKERS, CAST IRON, CATENARY
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.

COAL CARBONIZING APPARATUS
Combustion Engrg. Corp., N. Y.

COAL CRUSHERS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., Columbus, O.
Orton Crane & Shovel Co., Chicago, Ill.
Pennsylvania Crusher Co., Phila.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Strong-Scott Mfg. Co., Minneapolis, Minn.
Webster & Weller Mfg. Co., The, Chicago.

RECENT INDUSTRIAL POWER STATIONS

RECENT industrial power stations completed or in progress include work for the following clients: Vacuum Oil Company, Atmospheric Nitrogen Corporation, National Carbon Company, Inc., Pittsburgh Plate Glass Company, S K F Ball Bearing Company, American Sugar Refining Company, Mathieson Alkali Works, Inc., Bethlehem Steel Company, Westinghouse Lamp Company, United States Rubber Company, The Flintkote Company, Pacific Coast Condensed Milk Company, Standard Underground Cable Company, Firestone Tire & Rubber Company.

The work is varied. It includes the building of new steam and power stations, increasing the capacity of present plants, revamping present equipment to meet demands of economy, and rehabilitating old plants.

Illustrated is the Twin Cities Steam Power Plant of the Ford Motor Company at St. Paul.

STONE & WEBSTER ENGINEERING CORPORATION

COAL STORAGE EQUIPMENT
Allen-Sherman-Hoff Co., Phila.
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

COAL WEIGHING AND MEASURING EQUIPMENT
Beaumont Co., R. H., Phila.
C. J. Mfg. Co., Philadelphia, Pa.
Richardson Scale Co., Clifton, N. J.
Webster & Weller Mfg. Co., The, Chicago.

COATINGS, PROTECTIVE
Dampney Co. of Am., Boston.
Quigley Furnace Specialties Co., Inc., New York, N. Y.

COCKS, AIR AND STEAM
Dart Mfg. Co., E. M., Providence, R. I.
Homestead Valve Mfg. Co., Coraopolis, Pa.

COILS AND BENDS
Badger & Sons Co., E. B., Boston
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.

COMBUSTION ENGINEERS
Boiler Engrg. Co., Newark, N. J.

COMBUSTION (CO_2) RECORDERS
Brown Inst. Co., Phila., Pa.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago, Ill.

COMBUSTION CONTROL SYSTEMS
Bailey Meter Co., Cleveland.

COMPOUND PIPE JOINT
Key Boiler Equipment Co., E. St. Louis, Ill.
Dixon Crucible Co., Jos., Jersey City, N. J.
Smooth-On Mfg. Co., Jersey City.

CONDENSER TUBE CLEANERS
Lagonda Mfg. Co., Springfield, O.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

CONDENSERS
Binks Mfg. Co., Chicago, Ill.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Ingersoll-Rand Co., New York.
Manistee Iron Works, Manistee.
Schutte & Koerting Co., Phila.
Superheater Co., New York.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

CONSULTING ENGINEERS
Stone & Webster, Inc., Boston.

CONVEYORS
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Combustion Engrg. Corp., N. Y.
Detrick Co., M. H., Chicago.
Fairfield Engrg. Co., Marion, O.
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Company, Chicago.
Stephens-Adamson Mfg. Co., Aurora, Ill.
Webster & Weller Mfg. Co., The, Chicago.

COOLERS, OIL
Griscom-Russell Co., New York.
Schutte & Koerting Co., Phila.
Wheeler Mfg. Co., C. H., Phila.

COOLING SYSTEMS
Badger & Sons Co., E. B., Boston
Binks Mfg. Co., Chicago, Ill.
Marley Co., The, Kansas City.
Sturtevant Co., B. F., Boston.
Yarnall-Waring Co., Phila.

COOLING TOWERS
Foster Wheeler Corp., New York.
Marley Co., Kansas City, Mo.
Wheeler Mfg. Co., C. H., Phila.

COUNTERS, REVOLUTION
Lonergan Co., J. E., Phila., Pa.

COUPLINGS, COMPRESSION SHAFT
Nicholson & Co., W. H., Wilkes-Barre, Pa.

COUPLINGS, FLEXIBLE
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Terry Steam Turbine Co., The, Hartford, Conn.

COUPLINGS, UNION
Central Forging Co., Catawissa.
Dart Mfg. Co., E. M., Providence, R. I.
Grinnell Co., Inc., Providence.
Walworth Co., Boston.

CRANES, CRAWLING AND LOCOMOTIVE
Link-Belt Co., Chicago, Ill.
Orton Crane & Shovel Co., Chicago, Ill.

CRANES, TRAVELING
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

CRUSHING AND GRINDING MACHINERY
Pennsylvania Crusher Co., Phila.

DEAERATORS
Elliott Co., Jeannette, Pa.

DE-CONCENTRATOR
Henszey De-Concentrator Co. Watertown, Wis.

DESIGNERS & BUILDERS, POWER PLANT
Stone & Webster, Inc., Boston.

DETECTOR, CORROSION
Rice & Co., Cyrus Wm., Pittsburgh, Pa.

DRYERS, ROTARY AND WASTE HEAT
Fuller Lehigh Co., Fullerton, Pa.

DUCTS, AIR & GAS
Littleford Bros., Cincinnati,

DUST SWEEPING SYSTEMS
Allen & Billmyre Co., Inc., N. Y.

ECONOMIZERS
Babcock & Wilcox Co., The, N.Y.
Foster Wheeler Corp., N. Y.

EJECTORS
Elliott Co., Jeannette, Pa.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

EJECTORS, SEWAGE
Nash Engrg. Co., South Norwalk, Conn.

ELECTRICAL SUPPLIES
Gen. Elec. Co., Schenectady.

ELECTRICAL WIRES AND CABLES
Gen. Elec. Co., Schenectady.

ELEVATORS
Otis Elevator Co., New York.

ELIMINATORS, AUTO, STEAM
Nicholson & Co., W. H., Wilkes-Barre, Pa.

ENGINE STOPS, AUTOMATIC
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

FANS, ELECTRIC
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.

FANS, EXHAUST AND VENTILATING
Carling Turbine Blower Co., Worcester, Mass.
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.
Sturtevant Co., B. F., Boston.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

FEED WATER FILTERS
Filtrators Co., Inc., New York,

FEED WATER HEATERS AND PURIFIERS
Cochrane Corp., Philadelphia.
Elliott Company, Jeannette, Pa.
Foster Wheeler Corp., New York.
Griscom-Russell Co., New York.
Hoppes Mfg. Co., Springfield, O.
National Pipe Bending Co., New Haven, Conn.
Scaife & Sons Co., Wm. B., Oakmont, Pa.
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.
Swartwout Co., Cleveland.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp., New York.

FEED WATER TREATMENT
Dearborn Chemical Co., Chicago.
Filtrators Co., Inc., New York,
Garratt-Callahan Co., Chicago.
Griscom-Russell Co., New York.
National Aluminate Corp., Chicago, Ill
Scaife & Sons Co., Wm. B., Oakmont, Pa.

FEED WATER TREATMENT SERVICE
Rice & Co., Cyrus Wm., Pittsburgh, Pa.

FILTERS, AIR
Allen & Billmyre Co., Inc., N. Y.
Connor Co., Inc., W. B., N. Y.

FILTERS, OIL
Burt Mfg. Co., The, Akron, O.
Nugent & Co., Wm. W., Chicago.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 166

ENGINES, GAS AND GASOLINE
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago.
Ingersoll-Rand Co., New York,
Sterling Eng. Co., Buffalo.
Titusville Iron Works Co., Titusville, Pa.
Worthington Pump & Mach. Corp., New York.

ENGINES, OIL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Bethlehem Steel Co., Bethlehem.
Fairbanks, Morse & Co., Chicago.
Ingersoll-Rand Co., New York,
Sterling Eng. Co., Buffalo.
Worthington Pump & Mach. Corp., New York.

ENGINES, PUMPING
Murray Iron Works, Burlington, Iowa.

ENGINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Murray Iron Works, Burlington, Iowa.
Skinner Engine Co., Erie, Pa.
Sturtevant Co., B. F., Boston.
Titusville Iron Works Co., Titusville, Pa.
Troy Eng. & Mach. Co., Troy, Pa.

EVAPORATORS
Foster Wheeler Corp., New York.

EVAPORATORS, WATER
Griscom-Russell Co., New York.

EXHAUST HEADS
Burt Mfg. Co., The, Akron, O.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Swartwout Co., Cleveland.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.

EXPANDERS, TUBE
Nicholson & Co., W. H., Wilkes-Barre, Pa.

FILTERS, WATER
Cochrane Corp., Philadelphia.
Filtrators Co., Inc., New York,
Scaife & Sons Co., Wm. B., Oakmont, Pa.

FIRE BRICK
Harbison-Walker Refract. Co., Pittsburgh, Pa.
McLeod & Henry Co., Troy, N. Y.

FIRE BRICK CEMENT
McLeod & Henry Co., Troy, N. Y.

FIRE CLAY
Lavino and Co., E. J., Phila.,
Refractory & Eng'r'g Corp., N. Y.

FIRE HYDRANTS
Howard Iron Works, Buffalo.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.

FITTINGS, COMPRESSION
Nugent & Co., Wm. W., Chicago.

FITTINGS, FLANGE AND PIPE
Fisher Governor Co., The, Marshalltown, Iowa.
Grinnell Co., Inc., Providence.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Limbert & Co., Geo. B., Chicago.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Walworth Co., Boston.

FLANGES
Dart Mfg. Co., E. M., Providence, R. I.
Limbert & Co., Geo. B., Chicago.

FLOATS
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Reliance Gauge Column Co., Cleveland.

FLOW METERS
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Republic Flow Meters Co., Chicago, Ill.

FLUE CLEANERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Co., Detroit, Mich.
General Specialty Co., Buffalo.
Pierce Co., Wm. B., Buffalo.
Vulcan Soot Cleaner Co., Du Bois, Pa.

FURNACE BOTTOMS, CAST IRON, AIR-COOLED
Allen-Sherman-Hoff Co., Phila.

FURNACE CONSTRUCTION AND REPAIR
Pilbrico Jointless Firebrick Co., Chicago, Ill.

FURNACE FIRE OBSERVERS
Springfield Boiler Co., Springfield, Ill.

FURNACE SURFACES, WATER COOLED
Combustion Engrg. Corp., N. Y.
Foster Wheeler Corp., New York,
Fuller Lehigh Co., Fullerton, Pa.
Superheater Co., New York.

FURNACE WALLS
Combustion Engrg. Corp., N. Y.
Lavino and Co., E. J., Phila.,
Superheater Co., New York.

FURNACES
Combustion Engrg. Corp., N. Y.
Erie City Iron Works, Erie, Pa.
Riley Stoker Corp., Worcester,

FURNACES, CONSTRUCTION
Erie City Iron Works, Erie, Pa.

FURNACES, WATER COOLED
Erie City Iron Works, Erie, Pa.

GAS PRODUCERS
Wellman - Seaver - Morgan Co., The, Cleveland, Ohio.

GASKETS
Darcoid Co., Inc., New York.
"Flexitallic" Gasket Co., Camden, N. J.
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Johns-Manville Corp., New York.
Metallo Gasket Co., New Brunswick, N. J.
Smooth-On Mfg. Co., Jersey City.

GASKETS, ASBESTOS, STEEL
"Flexitallic" Gasket Co., Camden, N. J.

GAUGE COCKS
Lonergan Co., J. E., Phila., Pa.
Reliance Gauge Column Co., Cleveland.

GAUGE GLASSES
Jenkins Bros., New York, N. Y.
Libbey Glass Mfg. Co., The, Toledo, O.

GAUGE TESTERS
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Fisher Governor Co., The, Marshalltown, Iowa.

GAUGES, DRAFT
Bailey Meter Co., Cleveland, O.
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Pierce Co., Wm. B., Buffalo.
Republic Flow Meters Co., Chicago.

GAUGES, LIQUID LEVEL
Bristol Co., The, Waterbury.
Republic Flow Meters Co., Chicago.

GAUGES, PRESSURE AND RECORDING
Bristol Co., The, Waterbury.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Lonergan Co., J. E., Phila., Pa.

GAUGES, WATER
Lonergan Co., J. E., Phila., Pa.
Reliance Gauge Column Co., Cleveland.
Yarnall-Waring Co., Phila.

GEARS, DOUBLE HELICAL
De Laval Steam Turbine Co., Trenton, N. J.
Terry Steam Turbine Co., The, Hartford, Conn.

GEARS, REDUCTION
De Laval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannette, Pa.
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATING SETS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Carling Turbine Blower Co., Worcester, Mass.
Fairbanks, Morse & Co., Chicago.
Moore Steam Turbine Corp., Wellsville, N. Y.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GENERATORS, ELECTRIC
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Elliott Co., Jeannette, Pa.
Gen. Elec. Co., Schenectady.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

GOVERNORS, ENGINE
Pickering Governor Co., Portland, Conn.

GOVERNORS, PUMP
Atlas Valve Co., Newark, N. J.

Holding thin hot oil at high pressure

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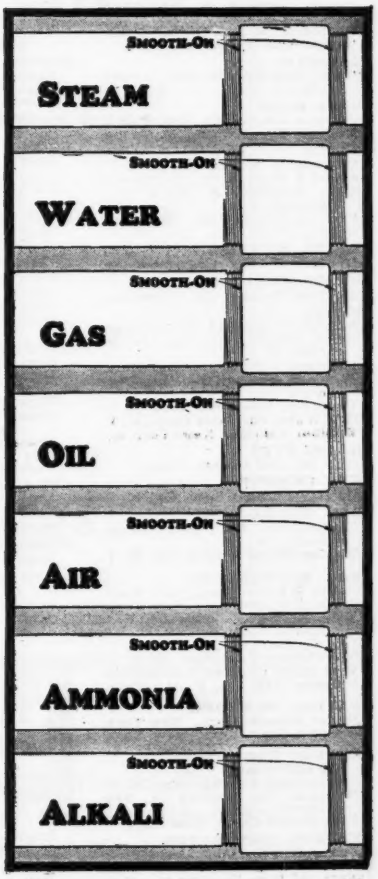

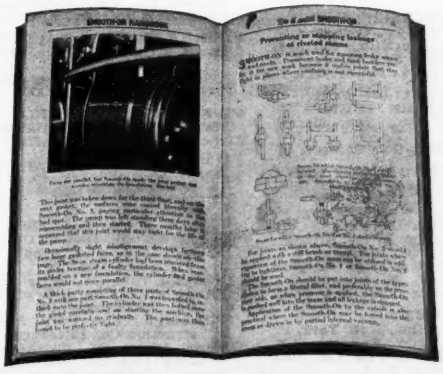

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Pickering Governor Co., Portland, Conn.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.

GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

GRATE BARS
Flynn & Emrich Co., Baltimore
McClave-Brooks Co., Scranton,

GRATES
Babcock & Wilcox Co., N. Y.
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., Goshen, Ind.
McClave-Brooks Co., Scranton,
Neemes Fdry., Inc., Troy, N. Y

GRATES, DUMPING
McClave-Brooks Co., Scranton,

GRATES, SHAKING
McClave-Brooks Co., Scranton,

GREASE
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Tide Water Oil Sales Corp., N. Y.
Vacuum Oil Co., New York.

GREASE CUPS
(See Oil and Grease Cups.)

GUNS, CEMENT
Quigley Furnace Spec. Co., N. Y.

GUNS, REFRACTORY
Cement-Gun Co., Inc., Allentown, Pa.
Quigley Furnace Spec. Co., N. Y.

HEAT EXCHANGERS
Foster Wheeler Corp, New York.
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.
Superheater Co., New York.
Vogt Mach. Co., Henry, Louisville.
Wheeler Mfg. Co., C. H., Phila.

HEATERS, BLEEDER
Foster Wheeler Corp., New York,
Griscom-Russell Co., New York.

HEATERS FOR SPECIAL PURPOSES
Combustion Engrg. Corp., N. Y.
National Pipe Bending Co., New Haven, Conn.
Prat-Daniel Corp., New York.

HEATERS, HOT WATER
Foster Wheeler Corp., New York,
Griscom-Russell Co., New York.
National Pipe Bending Co., New Haven, Conn.

HEATERS, OIL
National Pipe Bending Co., New Haven, Conn.
Wheeler Mfg. Co., C. H., Phila

HEATERS, STORAGE
National Pipe Bending Co., New Haven, Conn.

HOISTS
Orton Crane & Shovel Co., Chicago, Ill.
Sullivan Machinery Co., Chicago.

HOISTS, SKIP
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila.
Fairfield Engrg. Co., Marion, O.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

HOISTS, TRAVELING
Orton Crane & Shovel Co., Chicago, Ill.

HOPPERS AND BINS, COAL AND ASH
Allen-Sherman-Hoff Co., Phila.
Beaumont Co., R. H., Phila.
Combustion Engrg. Corp., N. Y.
Connery & Co., Inc., Phila.
Littleford Bros., Cincinnati,

HYDROMETERS
Taylor Inst. Cos., Rochester.

HYGRODIEKS
Taylor Inst. Cos., Rochester.

ICE MAKING & REFRIGERATING MACHINERY
Ingersoll-Rand Co., New York,
Vogt Mach. Co., Henry, Louisville.

INDICATORS, ENGINE
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.

INJECTORS AND INSPIRATORS
Schutte & Koerting Co., Phila.
Superheater Co., The, New York.

INSTRUMENTS, ELECTRICAL
Gen. Elec. Co., Schenectady.
Weston Elec. Inst. Corp., Newark,

INSTRUMENTS, INDICATING
Weston Elec. Inst. Corp., Newark,

INSTRUMENTS, RECORDING
Simplex Valve & Meter Co., Philadelphia, Pa.

INSULATING MATERIAL
Carey Co., Philip, Cincinnati.
Gen. Elec Co., Schenectady.
Johns-Manville Corp, New York.
Refractory & Engineering Corp., New York.

JOINTS EXPANSION
Badger & Sons Co., E. B., Boston
Foster Wheeler Corp., New York.
Howard Iron Works, Buffalo.
Littleford Bros., Cincinnati.
Wheeler Mfg. Co., C. H., Phila.

LINING, FURNACE
Lavino and Co., E. J., Phila.,
Norton Co., Worcester, Mass.
Refractory & Engineering Corp., New York.

LININGS, COAL BUNKER
Walles Dove-Hermiston Corp., New York, N. Y.

LOADERS AND UNLOADERS
Fairfield Engrg. Co., Marion, O
Jeffrey Mfg. Co., Columbus, O.
Link-Belt Co., Chicago, Ill.
Stephens-Adamson Mfg. Co., Aurora, Ill.

LUBRICANTS
Dearborn Chemical Co., Chicago.
Dixon Crucible Co., Jos., Jersey City, N. J.
Keystone Lubricating Co., Phila.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Tide Water Oil Sales Corp., N. Y.
Vacuum Oil Co., New York.

LUBRICATORS
Keystone Lubricating Co., Phila.
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.

LUBRICATORS, FORCED FEED
Manzel Bros. Co., Buffalo, N. Y.

MECHANICAL DRAFT APPARATUS
Coppus Engrg. Corp., Worcester.
Prat-Daniel Corp., New York.

NOZZLES FOR ALL PURPOSES
Connor Co., Inc., The W. B., New York, N. Y.
Marley Co., Kansas City, Mo.
Binks Mfg. Co., Chicago, Ill.
Schutte & Koerting Co., Phila.

OIL AND GREASE CUPS
Keystone Lubricating Co., Phila.
Lonergan Co., J. E., Phila., Pa.

OIL BURNING EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Peabody Engrg. Corp., N. Y.
Schutte & Koerting Co., Phila.

OIL, COAL, GAS BURNER
Peabody Engrg. Corp., N. Y.

OIL PURIFIERS
De Laval Separator Co., N. Y.
De Laval Steam Turbine Co., Trenton, N. J.
Nugent & Co., Wm. W., Chicago.

OIL SEPARATORS
De Laval Separator Co., N. Y.
Elliott Co., Jeannette, Pa.
Nugent & Co., Wm. W., Chicago.
Wright-Austin Co., Detroit.

OIL TANKS
Littleford Bros., Cincinnati,
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.

OILING SYSTEMS
Burt Mfg. Co., The, Akron, O.
De Laval Separator Co., N. Y.
Nugent & Co., Wm. W., Chicago.

OILS, LUBRICATING
Dearborn Chemical Co., Chicago.
Standard Oil Co. (Indiana), Chicago, Ill.
Texas Co., The, New York, N. Y.
Tide Water Oil Sales Corp., N. Y.
Vacuum Oil Co., New York.

PACKING, ASBESTOS
Garlock Pkg. Co., Palmyra, N.Y.
Ric-wil Co., Cleveland, Ohio.

PACKING, CENTRIFUGAL PUMP
Allpax Co., Inc., The, Mamaroneck, N. Y.
Conneaut Pkg. Co., Conneaut, O.
Cooke Seal Ring Co., Chicago,
Garlock Pkg. Co., Palmyra, N. Y.

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Sturtevant Co., B. F., Boston.
Wing Mfg. Co., L. J., New York.

METERS, AIR AND GAS
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.

METERS, BOILER
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.
Yarnall-Waring Co., Phila.

METERS, COAL
Bailey Meter Co., Cleveland, O.
C. J. Mfg. Co., Philadelphia, Pa.
Republic Flow Meters Co., Chicago.

METERS, FEED WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.
Simplex Valve & Meter Co., Philadelphia, Pa.
Worthington Pump & Mach. Corp., New York.

METERS, STEAM
Bailey Meter Co., Cleveland, O.
Brown Inst. Co., Phila., Pa.
Builders Iron Fdry., Providence.
Republic Flow Meters Co., Chicago.
Simplex Valve & Meter Co., Philadelphia, Pa.

METERS V NOTCH
Yarnall-Waring Co., Phila.

METERS, WATER
Bailey Meter Co., Cleveland, O.
Builders Iron Fdry., Providence.
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Republic Flow Meters Co., Chicago.

MOTORS
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Fairbanks, Morse & Co., Chicago.
Gen. Elec. Co., Schenectady.
Westinghouse Elec. & Mfg. Co., East Pittsburgh.

PACKING, COMPRESSOR
Cooke Seal Ring Co., Chicago,

PACKING, FLAX
Garlock Pkg. Co., Palmyra, N. Y.

PACKING, MECHANICAL
Cooke Seal Ring Co., Chicago,

PACKING, METALLIC
Conneaut Pkg. Co., Conneaut, O.
Cooke Seal Ring Co., Chicago,
Crane Packing Co., Chicago, Ill.
Garlock Pkg. Co., Palmyra, N. Y.

PACKING, METALLIC FOR CONDENSER TUBES
Allpax Co., Inc., The, Mamaroneck, N. Y.
Crane Packing Co., Chicago, Ill.

PACKING, PISTON AND ROD
Allpax Co., Inc., The, Mamaroneck, N. Y.
Conneaut Pkg. Co., Conneaut, O.
Crane Packing Co., Chicago, Ill.
Darcoid Co., Inc., New York.
Garlock Pkg. Co., Palmyra, N. Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Johns-Manville Corp., New York.

PACKING, SHEET
Darcoid Co., Inc., New York.
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Pkg. Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Johns-Manville Corp., New York.

PACKING, VALVE STEM
Allpax Co., Inc., The, Mamaroneck, N. Y.
Conneaut Pkg. Co., Conneaut, O.
Darcoid Co., Inc., New York.
Garlock Pkg. Co., Palmyra, N.Y.
Johns-Manville Corp., New York.

PAINT, ACID, ALKALI & WATER RESISTANT
Quigley Furnace Spec. Co., N. Y.

PAINT, ANTI-CORROSIVE
Dampney Co. of Am., Boston.
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, FLOOR
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, GRAPHITE
Dixon Crucible Co., Jos., Jersey City, N. J.

PAINT, HEAT RESISTING
Dampney Co. of Am., Boston.
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, METAL
Dampney Co. of Am., Boston.

PAINT, PROTECTIVE
Walles Dove-Hermiston Corp., New York, N. Y.

PAINT, STEEL PRESERVATIVE
Dampney Co. of Am., Boston.

PATCHING MATERIAL REFRACTORY
Quigley Furnace Spec. Co., N. Y.

PIPE BENDING
Badger & Sons Co., E. B., Boston
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Spang, Chalfant & Co., Inc., Pittsburgh, Pa.
Walworth Co., Boston.

PIPE CLAMPS, COUPLINGS AND JOINTS
Grinnell Co., Inc., Providence.

PIPE COILS
Badger & Sons Co., E. B., Boston
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Pipe Bending Co., New Haven, Conn.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Spang, Chalfant & Co., Inc., Pittsburgh, Pa.
Superheater Co., The, New York.
Vogt Mach. Co., Henry, Louisville.

PIPE COVERINGS
Carey Co., Philip, Cincinnati.
Johns-Manville Corp., New York
Ric-Wil Co., Cleveland.

PIPE CUTTERS
Curtis & Curtis Co., The, Bridgeport, Conn.
Toledo Pipe Threading Mach. Co., The, Toledo, O.
Walworth Co., Boston.

PIPE FABRICATORS
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Spang, Chalfant & Co., Inc., Pittsburgh, Pa.

PIPE HANGERS & SUPPLIES
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.

PIPE THREADING MACHINES
Curtis & Curtis Co., The, Bridgeport, Conn.
Toledo Pipe Threading Mach. Co., The, Toledo, O.

PIPE, WROUGHT STEEL
National Tube Co., Pittsburgh.
Reading Iron Co., Reading, Pa.

PIPING
Baker Co., Inc., R. H., Cambridge, Mass.
Bethlehem Steel Co., Bethlehem, Pa.
Connery & Co., Inc., Phila.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
National Tube Co., Pittsburgh.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Reading Iron Co., Reading, Pa.
Spang, Chalfant & Co., Inc., Pittsburgh, Pa.
Walworth Co., Boston.

PIPING CONTRACTING MANUFACTURERS
Baker Co., Inc., R. H., Cambridge, Mass.
Grinnell Co., Inc., Providence.
Limbert & Co., Geo. B., Chicago.
Midwest Piping & Supply Co., St. Louis, Mo.
Pittsburgh Piping & Equipment Co., Pittsburgh, Pa.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Power Piping Co., Pittsburgh.
Pope, Wm. A., Chicago.
Spang, Chalfant & Co., Inc., Pittsburgh, Pa.

PLATE STEEL CONSTRUCTION
Littleford Bros., Cincinnati, O.

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★ *Lower Bearing Temperature*

★ *Lower Oil Consumption*

★ *Perfect Lubrication*

★ *No Carbon Trouble*

★ *No Sticking Piston Rings*

THESE are the five points which lead to the endorsement of Texaco Algol Oil for the Fairbanks-Morse Diesel Engines in the power plant of one well-known southeastern utility company.

The chief engineer of the plant highly recommends Texaco Algol Oil for Diesel lubrication. Two other oils had been tried out. Both were excellent oils made especially for the work, but Texaco Algol Oil proved so superior that it is the *one* lubricant now used exclusively at this installation.

Texaco Algol Oil is the effective lubricant for all Fairbanks-Morse and other engines of the Diesel and semi-Diesel type. Its high lubricating qualities and uniformity are recognized everywhere—and Texaco Lubrication Service is always available to cooperate in securing the most effective lubricating practices.

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POWER PLANT MANAGEMENT
Stone & Webster, Inc., Boston.

POWER TRANSMITTING MACHINERY
Webster & Weller Mfg. Co., The, Chicago.

PREHEATER AND HEAT EXCHANGERS
Prat-Daniel Corp., New York.

PROTECTIVE COATINGS
Dampney Co. of Am., Boston.

PULVERIZED COAL BURNERS
Erie City Iron Works, Erie, Pa.

PULVERIZED FUEL EQUIPMENT
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Foster Wheeler Corp., N. Y.
Fuller Lehigh Co., Fullerton, Pa.
Riley Stoker Corp., Worcester.

PULVERIZERS, COAL
Bethlehem Steel Co., Bethlehem.
Combustion Engrg. Corp., N. Y.
Fuller Lehigh Co., Fullerton, Pa.
Jeffrey Mfg. Co., The, Columbus.
Pennsylvania Crusher Co., Phila.
Riley Stoker Corp., Worcester.
Strong-Scott Mfg. Co., Minneapolis, Minn.

PUMPING SYSTEMS, AIR LIFT
Ingersoll-Rand Co., New York.
Sullivan Machinery Co., Chicago.

PUMPS
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, BOILER FEED
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Ingersoll-Rand Co., New York.
Kingsford Fdry. & Mach. Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., The, Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Machy. Corp., New York.

PUMPS, CENTRIFUGAL
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Coppus Engrg. Corp., Worcester.
De Laval Steam Turbine Co., Trenton, N. J.
Fairbanks, Morse & Co., Chicago.
Foster Wheeler Corp., New York.
Frederick Iron & Steel Co., Frederick, Md.
Ingersoll-Rand Co., New York.
Kingsford Fdry. & Mach Wks., Oswego, N. Y.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville. N. Y
Nash Engrg. Co., S. Norwalk.
Platt Iron Works, Dayton, O.
Terry Steam Turbine Co., Hartford, Conn.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.
Wheeler Mfg. Co., C. H., Phila.
Worthington Pump & Mach. Corp, New York.

PUMPS, DEEP WELL
Fairbanks, Morse & Co., Chicago.
Platt Iron Works, Dayton, O.
Westco - Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, ELECTRIC
Frederick Iron & Steel Co., Frederick, Md.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, ELEVATOR AND FIRE
De Laval Steam Turbine Co., Trenton. N. J.
Frederick Iron & Steel Co., Frederick, Md.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, GENERAL SERVICE
Frederick Iron & Steel Co., Frederick, Md.
Nash Engrg. Co., S. Norwalk.
Platt Iron Wks., Dayton, O.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, HYDRAULIC PRESSURE
Connor Co., Inc., The W. B., New York, N. Y.
Frederick Iron & Steel Co., Frederick, Md.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.

PUMPS, JET
Manistee Iron Works, Manistee.

PUMPS, OIL
Connor Co., Inc., The W. B., New York, N. Y.
Frederick Iron & Steel Co., Frederick, Md.
Lonergan Co., J. E., Phila., Pa.
Manzel Bros. Co., Buffalo, N. Y.
Nugent & Co., Wm. W., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco - Chippewa Pump Co., Davenport, Iowa.

PUMPS, POWER
Fairbanks, Morse & Co., Chicago.
Lecourtenay Co., Newark, N. J.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mas.
Westco-Chippewa Pump Co., Davenport, Iowa.
Worthington Pump & Mach. Corp., New York.

PUMPS, ROTARY
Manistee Iron Works, Manistee.
Platt Iron Works, Dayton, O.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, STEAM
Platt Iron Works, Dayton, O.
Titusville Iron Works Co., Titusville, Pa.

PUMPS, TURBINE
Moore Steam Turbine Corp., Wellsville, N. Y.
Terry Steam Turbine Co., The, Hartford, Conn.

PUMPS, VACUUM
Allen & Billmyre Co., Inc., N. Y.
Foster Wheeler Corp., New York.
Ingersoll-Rand Co., New York.
Manistee Iron Works, Manistee.
Nash Engrg. Co., S. Norwalk.
Sullivan Machy. Co., Chicago.
Warren Steam Pump Co., Inc., Warren, Mass.
Wheeler Mfg. Co., C. H., Phila.

PUMPS, WATERWORKS
Allis-Chalmers Co., Milwaukee.
Frederick Iron & Steel Co., Frederick, Md.
Lecourtenay Co., Newark, N. J.
Manistee Iron Works, Manistee.
Moore Steam Turbine Corp., Wellsville, N. Y.
Platt Iron Works, Dayton, O.
Warren Steam Pump Co., Inc., Warren, Mass.
Westco-Chippewa Pump Co., Davenport, Iowa.

PURIFIERS, BOILER FEED
Cochrane Corp., Philadelphia.
Hoppes Mfg. Co., Springfield, O.
Scaife & Sons Co., Wm. B., Oakmont, Pa.

PURIFIERS, STEAM
Marley Co., Kansas City, Mo.

PYROMETERS
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Republic Flow Meters Co., Chicago, Ill.
Superheater Co., The, N. Y.
Taylor Inst. Cos., Rochester.

QUENCHERS, ASH
Allen-Sherman-Hoff Co., The Philadelphia, Pa.

RECORDERS, LIQUID LEVEL
Bristol Co., The, Waterbury.
Taylor Inst. Cos., Rochester.

RECORDERS, PRESSURE
Crosby Steam Gage & Valve Co., Boston.

RECORDING INSTRUMENTS
Bristol Co., The, Waterbury.
Simplex Valve & Meter Co., Philadelphia, Pa.

REFRACTORY CEMENT
Quigley Furnace Spec. Co., N. Y.

REFRACTORIES
Faulkner Refractories Co., J. A., Youngstown, Ohio.
Harbison-Walker Refract. Co., Pittsburgh.
Lavino and Co., E. J., Phila.
McLeod & Henry Co., Troy, N.Y.
Norton Co., Worcester, Mass.
Refractory & Eng'r'g Corp., N. Y.
Rust Engrg. Co., Pittsburgh.

REGULATORS, DAMPER
Atlas Valve Co., Newark, N. J.
Brown Inst. Co., Phila., Pa.
Kieley & Mueller, Inc., New York.
National Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

REGULATORS, FAN ENGINE
Atlas Valve Co., Newark, N. J.
National Regulator Co., Chicago.

REGULATORS, FEED WATER
Atlas Valve Co., Newark, N. J.
Bailey Meter Co., Cleveland.
Chaplin-Fulton Mfg. Co., Pittsburgh.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York.
Squires Co., C. E., Cleveland.
Swartwout Co., Cleveland.
Wright-Austin Co., Detroit.

REGULATORS, PRESSURE
Fisher Governor Co., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Kieley & Mueller, Inc., New York.
National Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.
Squires Co., C. E., Cleveland.
Strong Carlisle & Hammond Co., Cleveland, Ohio.
Watson & McDaniel Co., Phila.

REGULATORS, STOKER ENGINE
National Regulator Co., Chicago.

REGULATORS, TEMPERATURE
Atlas Valve Co., Newark, N. J.
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
National Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Sarco Co., Inc., New York, N. Y.

RUST PREVENTIVES
Dearborn Chem. Co., Chicago.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 166

SCALE REMOVERS (Mechanical)
General Specialty Co., Buffalo.
Lagonda Mfg. Co., Springfield, O.
Liberty Mfg. Co., Pittsburgh.
Pierce Co., Wm. B., Buffalo.
Roto Co., The, Newark, N. J.

SCRAPERS, CABLE DRAG
Beaumont Co., R. H., Phila.

SEAL RINGS
Cooke Seal Ring Co., Chicago, Ill.

SEPARATORS AND EXTRACTORS, STEAM AND OIL
Cochrane Corp., Philadelphia.
Direct Separator Co., Syracuse.
Hoppes Mfg. Co., Springfield, O.
Illinois Engrg. Co., Chicago.
Kieley & Mueller, Inc., New York.
Marley Co., Kansas City, Mo.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Wright-Austin Co., Detroit.

SEPARATORS, STEAM AND AIR
Barrett Machine Co., Pittsburgh.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

SHAFTING
National Tube Co., Pittsburgh.

SHEET METAL WORKS
Littleford Bros., Cincinnati,

SHOVELS, STEAM, GAS AND ELECTRIC
Orton Crane & Shovel Co., Chicago, Ill.

SLUICING SYSTEMS, ASH
Allen-Sherman-Hoff Co., Phila.

SODIUM ALUMINATE
National Aluminate Corp., Chicago, Ill.

SOOT BLOWERS
Bayer Co., The, St. Louis, Mo.
Diamond Power Spec. Corp., Detroit, Mich.
Vulcan Soot Cleaner Co., Dubois, Pa.

SPEED REDUCERS, CHAIN
Morse Chain Co., Ithaca, N. Y.

SPRAY AIR WASHERS
Badger & Sons Co., E. B., Boston
Binks Mfg. Co., Chicago, Ill.

SPRAY COOLING SYSTEMS
Badger & Sons Co., E. B., Boston
Marley Co., The, Kansas City, Mo.
Yarnall-Waring Co., Phila.

SPRAY NOZZLES
Binks Mfg. Co., Chicago, Ill.
Marley Co., Kansas City, Mo.
Yarnall-Waring Co., Phila.

SPROCKET RIMS
Babbitt Steam Specialty Co., New Bedford, Mass.

STACKS, METAL
Connery & Co., Inc., Phila.
Littleford Bros., Cincinnati, O.
Prat-Daniel Corp., New York.
Vogt Mach. Co., Henry, Louisville.

STEAM GENERATING EQUIPMENT
Combustion Engrg. Corp., N. Y.

STEAM TRAPS
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua.
Cochrane Corp., Philadelphia.
Connor Co., Inc., W. B., N. Y.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Fisher Governor Co., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Johns-Manville Corp., New York.
Kieley & Mueller, Inc., New York.
Nicholson & Co., W. H., Wilkes-Barre, Pa.
Reliance Gauge Column Co., Cleveland.
Sarco Company, Inc., New York.
Squires Co., C. E., Cleveland.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Swartwout Co., Cleveland.
Watson & McDaniel Co., Phila.
Wright-Austin Co., Detroit.

STEEL, ALLOY
Bethlehem Steel Co., Bethlehem, Pa.

STEEL, STAYBOLT & ENGINE BOLT
Bethlehem Steel Co., Bethlehem, Pa.

STOCKS AND DIES
Curtis & Curtis Co., Bridgeport.
Toledo Pipe Threading Mach Co., The, Toledo, O.

STOKERS, CHAIN GRATE
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y
McClave-Brooks Co., Scranton
Riley Stoker Corp., Worcester.

STOKERS, HAND OPERATED
Flynn & Emrich Co., Baltimore.
Kelly Foundry & Mach. Co., The,, Goshen, Ind.
McClave-Brooks Co., Scranton

STOKERS, MECHANICAL
American Engrg. Co., Phila.
Babcock & Wilcox Co., N. Y.
Combustion Engrg. Corp., N. Y.
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore.
McClave-Brooks Co., Scranton
Riley Stoker Corp., Worcester.

STOKERS, OVERFEED
Detroit Stoker Co., Detroit.
Flynn & Emrich Co., Baltimore
McClave-Brooks Co., Scranton,
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STOKERS, UNDERFEED
American Engrg. Co., Phila.
Combustion Engrg. Corp., N. Y
Detroit Stoker Co., Detroit.
McClave-Brooks Co., Scranton
Riley Stoker Corp., Worcester.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

STRAINERS
Sarco Co., Inc., New York.
Wright-Austin Co., Detroit.

STRAINERS, OIL
Sarco Co., Inc., New York.

SUPERHEATERS, STEAM
Babcock & Wilcox Co., N. Y.
Badenhausen Corp., Cornwells Heights, Pa.
Foster Wheeler Corp., N. Y.
Marley Co., The, Kansas City, Mo.
Superheater Co., The. New York.

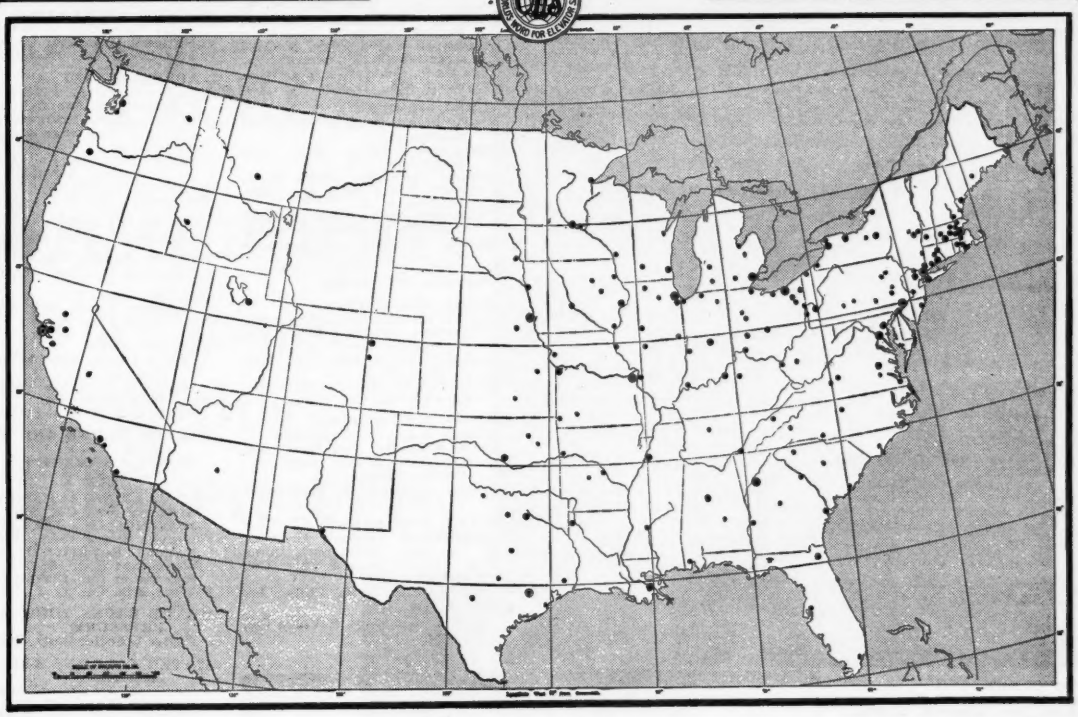
SWITCHBOARDS, ASBESTOS
Johns-Manville Corp., New York.

TACHOMETERS
Bristol Co., The, Waterbury.
Brown Inst. Co., Phila., Pa.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.

TANKS
Connery & Co., Inc., Phila.
Littleford Bros., Cincinnati, O.
Scaife & Sons, Wm. B., Oakmont, Pa.
Springfield Boiler Co., Springfield, Ill.
Titusville Iron Works Co., Titusville, Pa.
Vogt Mach. Co., Henry, Louisville.

TELESCOPIC OILERS
Nugent & Co., Wm. W., Chicago.

THERMOMETERS
Bristol Co., The, Waterbury.



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National Regulator Co., Chicago.
Taylor Inst. Co., Rochester.

THERMOMETERS, RECORDING AND INDICATING
Bristol Co., The, Waterbury.
Brown Instr. Co., Phila., Pa.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Taylor Inst. Co., Rochester.

TRACKWORK, INDUSTRIAL
Bethlehem Steel Co., Bethlehem, Pa.

TRAPS, COMPRESSED AIR
Armstrong Machine Wks., Three Rivers, Mich.
Nicholson & Co., W. H., Wilkes-Barre, Pa.

TRAPS, RADIATOR
Armstrong Machine Wks., Three Rivers, Mich.
Sarco Co., Inc., New York.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

TRAPS, RETURN
Bundy Steam Trap Co., Nashua.
Connor Co., Inc., W. B., N. Y.
Kieley & Mueller, Inc., New York.
Sarco Co., Inc., New York.

TRAPS, STEAM AND RADIATOR
Connor Co., Inc., W. B., N. Y.
Illinois Engrg. Co., Chicago.
Sarco Co., Inc., New York.

TRAPS, VACUUM
Armstrong Machine Wks., Three Rivers, Mich.
Bundy Steam Trap Co., Nashua.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.

TUBE CUTTERS
Lagonda Mfg. Co., Springfield, O.

TUBES, BOILER, CHARCOAL IRON
Bethlehem Steel Co., Bethlehem, Pa.

TUBING
Babcock & Wilcox Tube Co., The, Beaver Falls, Pa.
National Tube Co., Pittsburgh.

TUBING CONDENSER
Foster Wheeler Corp., N. Y.
Mace Co., Inc., Albert E., Boston.

TUBING, SEAMLESS STEEL
National Tube Co., Pittsburgh.

TURBINES, HYDRAULIC
DeLaval Steam Turbine Co., Trenton, N. J.

TURBINES, STEAM
Allis-Chalmers Mfg. Co., Milwaukee, Wis.
Carling Turbine Blower Co., Worcester, Mass.
DeLaval Steam Turbine Co., Trenton, N. J.
Elliott Co., Jeannete, Pa.
Gen. Elec. Co., Schenectady.
Moore Steam Turbine Co., Wellsville, N. Y.
Murray Iron Works, Burlington, Iowa.
Sturtevant Co., B. F., Boston.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.
Wing Mfg. Co., L. J., New York.

TURBO GENERATORS
Elliott Co., Jeannette, Pa.
Gen. Elec. Co., Schenectady.
Murray Iron Works, Burlington, Iowa.
Terry Steam Turbine Co., Hartford, Conn.
Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

UNDERGROUND HEATING SYSTEM
Baker Co., Inc., R. H., Cambridge, Mass.
Johns-Manville Corp., N. Y.
Ric-Wil Co., Cleveland.

UNIONS
Atlas Valve Co., Newark, N. J.
Central Forging Co., Catawissa.
Dart Mfg. Co., E. M., Providence, R. I.
Walworth Co., Boston.

VACUUM CLEANING SYSTEMS
Allen & Billmyre Co., Inc., N. Y.
Sturtevant Co., B. F., Boston.

VALVE DISCS
Garlock Pkg. Co., Palmyra, N.Y.
Goetze Gasket & Packing Co., New Brunswick, N. J.
Jenkins Bros., New York, N. Y.
Metallo Gasket Co., New Brunswick, N. J.

VALVES
Atlas Valve Co., Newark, N. J.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Vogt Mach. Co., Henry, Louisville.

VALVES, ALTITUDE
Kieley & Mueller, Inc., New York.
Simplex Valve & Meter Co., Philadelphia, Pa.

VALVES, AUTOMATIC CUT-OFF
Elliott Co., Jeannette, Pa.
Fisher Governor Co., The, Marshalltown, Iowa.

VALVES, AUTOMATIC STOP AND CHECK
Illinois Engrg. Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.

VALVES, BLOW-OFF
Barrett Machine Co., Pittsburgh.
Crosby Steam Gage & Valve Co., Boston.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Yarnall-Waring Co., Phila.

VALVES, BY-PASS
Jenkins Bros., New York, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.

VALVES, CHECK
Crosby Steam Gage & Valve Co., Boston.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Schutte & Koerting Co., Phila.
Walworth Co., Boston.

VALVES, FLOAT
Atlas Valve Co., Newark, N. J.
Crosby Steam Gage & Valve Co., Boston.
Fisher Governor Co., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Kieley & Mueller, Inc., New York.

VALVES, GATE
Chapman Valve Mfg. Co., Indian Orchard, Mass.
Crosby Steam Gage & Valve Co., Boston.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Vogt Mach. Co., Henry, Louisville.
Walworth Co., Boston.

VALVES, GLOBE
Crosby Steam Gage & Valve Co., Boston.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Pittsburgh Valve Fdry. & Construction Co., Pittsburgh, Pa.
Strong, Carlisle & Hammond Co., Cleveland, Ohio.
Vogt Mach. Co., Henry, Louisville.
Walworth Co., Boston.

VALVES, HYDRAULIC
Barrett Machine Co., Pittsburgh.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
Vogt Mach. Co., Henry, Louisville.
Yarnall-Waring Co., Phila.

VALVES, NON-RETURN
Illinois Engrg. Co., Chicago.
Kieley & Mueller, Inc., New York.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Strong, Carlisle & Hammond, Co., Cleveland, Ohio.

VALVES, POP SAFETY
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Crosby Steam Gage & Valve Co., Boston.
Lonergan Co., J. E., Phila., Pa.

VALVES, PUMP
Crosby Steam Gage & Valve Co., Boston.

To Find the Manufacturers' Advertisements of Products Listed Here, See Index Page 166

Fisher Governor Co., The, Marshalltown, Iowa.
Garlock Pkg. Co., Palmyra, N.Y.

VALVES, RADIATOR
Jenkins Bros., New York, N. Y.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.
National Regulator Co., Chicago.
Sarco Co., Inc., New York.

VALVES, REDUCING
Atlas Valve Co., Newark, N. J.
Chapin-Fulton Mfg. Co., Pittsburgh, Pa.
Elliott Company, Jeannette, Pa.
Fisher Governor Co., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Kieley & Mueller, Inc., New York.
National Regulator Co., Chicago.
Ruggles-Klingemann Mfg. Co., Salem, Mass.
Squires Co., C. E., Cleveland, O.
Watson & McDaniel Co., Phila.

VALVES, REGRINDING
Homestead Valve Mfg. Co., Coraopolis, Pa.
Kennedy Valve Mfg. Co., The, Elmira, N. Y.

VALVES, REGULATING
Atlas Valve Co., Newark, N. J.
National Regulator Co., Chicago.
Swartwout Co., Cleveland.

VALVES, RELIEF
Cochrane Corp., Philadelphia.
Consolidated Ashcraft Hancock Co., Inc., Bridgeport, Conn.
Crosby Steam Gage & Valve Co., Boston.
Fisher Governor Co., The, Marshalltown, Iowa.
Illinois Engrg. Co., Chicago.
Lonergan Co., J. E., Phila., Pa.

VALVES, RUBBER
Garlock Pkg. Co., Palmyra, N.Y.

VALVES, SIGHT FEED
Nugent & Co., Wm. W., Chicago.

VALVES, STEEL
Kennedy Valve Mfg. Co., The, Elmira, N. Y.

VALVES, STOP
Crosby Steam Gage & Valve Co., Boston.
Homestead Valve Mfg. Co., Coraopolis, Pa.
Schutte & Koerting Co., Phila.

VALVES, THREE AND FOUR WAY
Nicholson & Co., W. H., Wilkes-Barre, Pa.

VENTILATING APPARATUS
Badger & Sons Co., E. B., Boston
Burt Mfg. Co., The, Akron, O.
Coppus Engrg. Corp., Worcester.
National Regulator Co., Chicago.
Sturtevant Co., B. F., Boston.
Swartwout Co., Cleveland.
Wing Mfg. Co., L. J., New York.

WATER BACKS, HIGH & LOW PRESSURE
Foster Wheeler Corp., New York,

WATER COLUMNS AND ALARMS
Reliance Gauge Column Co., The, Cleveland, O.
Wright-Austin Co., Detroit.
Yarnall-Waring Co., Phila.

WATER COOLING EQUIPMENT
Marley Co., The, Kansas City, Mo.

WATER SOFTENING SYSTEMS
Cochrane Corp., Philadelphia.
Dearborn Chemical Co., Chicago.
Griscom-Russell Co., New York.
National Aluminate Corp., Chicago, Ill.
Scaife & Sons, Wm. B., Oakmont, Pa.

WATER TESTING EQUIPMENT
National Aluminate Corp., Chicago, Ill.

WATER WALLS
Combustion Engrg. Corp., N. Y.
Edge Moor Iron Co., Edge Moor.
Fuller Lehigh Co., Fullerton, Pa.

WEIGH LARRIES
Bartlett & Snow Co., The C. O., Cleveland, Ohio.
Beaumont Co., R. H., Phila.

WELDED HEADERS
Grinnell Co., Providence, R. I.
Midwest Piping & Supply Co., St. Louis, Mo.

WHISTLES
Lonergan Co., J. E., Phila., Pa.

WRENCHES
Walworth Co., Boston.

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Gate, globe, angle and check valves, in iron, iron-body bronze-mounted, all iron, steel and special material, and for a wide range of pressures. Malleable iron and brass or bronze-screwed pipe fittings. Cast iron flanged fittings and flanges. Send for catalog.

New York Chicago
Philadelphia San Francisco Seattle

The Kennedy Valve Mfg. Co., Elmira, N. Y.

Cleveland, Atlanta, El Paso, Los Angeles, Salt Lake City

DEPENDABLE STEEL PIPING

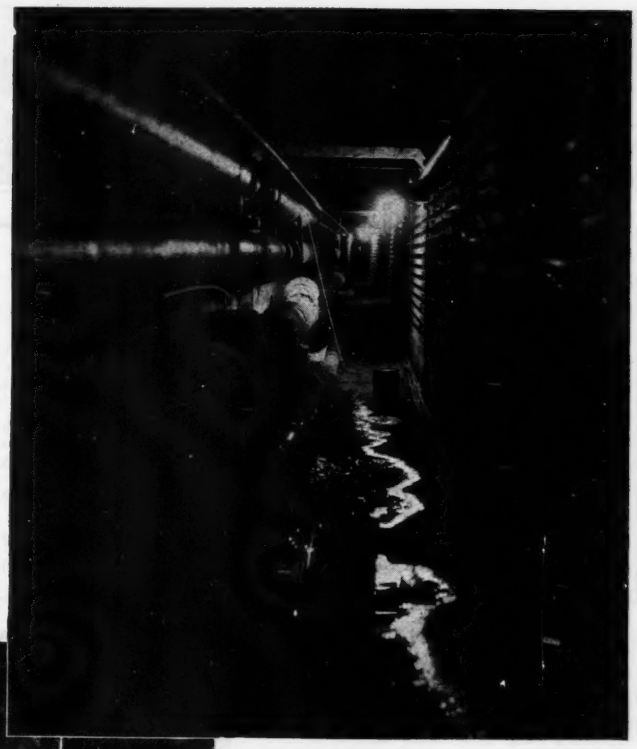
For Every Power Plant Requirement

SPANG WELDED

SPANG, CHALFANT and COMPANY, Inc.
CLARK BUILDING PITTSBURGH, PA.

STANDARD SEAMLESS

Heat Insulation is a "major" at this University!



A view of the underground steam piping at Purdue. Much of which is heat-insulated with Carey 85% Magnesia—efficiently protected against the cold and dampness of the tunnel.

The campus of Purdue University, La-Fayette, Indiana, where thirty-two buildings are heated from a single central plant.

COUNT on a college of technology to make the most of its B.T.U.s! Visit Purdue, for example, one of the leading technical universities of the Middle West—there you'll find the very finest in underground steam distribution equipment. And insulation!

More than nine thousand feet of piping, up to sixteen inches in size, *wears an overcoat of Carey 85% Magnesia.* Almost two miles of it, the economical super-protection for high temperature lines!

If you have a heating or insulating problem of any kind, you will spend a few hours to good advantage with Carey engineers. The services of the Carey staff are at your disposal, any time.

THE PHILIP CAREY COMPANY, *Lockland,* CINCINNATI, OHIO

Carey HEAT INSULATIONS

For every need . . . from residence to super power plant

SIGNBOARD SECTION

Quick Action Opportunities

CLASSIFIED RATES

Advertisements in the Signboard Section which come under the classification "Position Wanted," "Help Wanted," "Salesmen and Agencies," "Business Opportunities," "Patents and Patent Attorneys" and "Technical Books" will be set in type as shown below and published at the rate of

50 cents a line

each insertion, 6 words to a line; minimum sold, 4 lines.

For display of any advertisement under the classified headings see sizes and rates in column at right.

DISPLAY RATES

Advertisements in Signboard Section which comes under the classification "Equipment for Sale," "Equipment Wanted," "Educational and Instruction," and "Miscellaneous" are set in display space of the following sizes and at these rates.

1 in.	$ 5.50	4 in.	$20.80
2 in.	10.80	1 col. (8½ in.)	43.35
3 in.	15.90	2 col. (17 in.)	85.00

Not less than one inch to be sold in these classifications.

For advertising rates under other headings in this section, see column at left.

ENGINEERS WANTED

COMPRESSOR ENGINEER for research and development work with large and well-known corporation using compressors—age 30 to 35—Technical graduate—5 years' experience with compressor manufacturer in testing and trouble shooting—must be investigative type. Good opportunity in growing industry. Address Box 1018, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

HEAT TRANSFER equipment manufacturer desires Sales Engineers, Calculating Engineers and Designers experienced in the Power Plant, Petroleum, Refrigeration and Industrial Fields. Excellent opportunities for proper applicants. Give full information in first letter. All replies considered strictly confidential. Write Heat Transfer Products Inc., affiliated with American Locomotive Company, 30 Church St., New York, N. Y.

FREE BULLETINS

BULLETIN NO. 394. Covers Air Compressors, Tanks, Gasoline and Oil Engines and other items of power plant equipment.
Bulletin No. 397. Covers Cranes, Buckets and heavy equipment.
Write to Walter A. Zelnicker Supply Co., 511 Locust St., St. Louis, Mo.

MISCELLANEOUS

TO COMPANIES SEEKING RESPONSIBLE ENGINEERS the Signboard Section offers a valuable double service. The engineers who advertise for positions are subscribers to Power Plant Engineering which means that they are serious about their work and anxious to learn. Companies and managers often are able to fill positions in their plants with experienced, reliable men by answering these "positions wanted" advertisements. If the type of man you are looking for is not found in these advertisements, or needs experience somewhat out of the ordinary, an advertisement of your own under the "engineers wanted" heading setting forth your exact requirements will usually bring a number of replies from which you can select the most likely candidates for further interview.

POSITIONS WANTED

GRADUATE MECHANICAL ENGINEER now employed as Power Plant Chief Engineer desires a change. Seven years' experience on construction, maintenance and operation. 33 years of age and married. Location immaterial. Please write to Box 1014, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill.

EXPERIENCED ENGINEER seeking new position in large or medium sized plant. 44 years of age and married. 27 years in power plant work. Has been since 1922 Chief Engineer and Master Mechanic of a large textile plant. Leaving because plant has gone over to purchased power. Would like a position as assistant Chief Engineer in a large plant. Please write to Box 1015, Power Plant Engineering, 53 West Jackson Blvd., Chicago, Ill.

CHIEF OPERATING AND MAINTENANCE ENGINEER would like to make a new connection. Has had 15 years' experience with Diesel and steam, electric and industrial plants. Is married and able to locate in any part of the country. Can furnish excellent references. If you need a man who can run your plant as it should be run, write to Box 1013, Power Plant Engineering, 53 W. Jackson Blvd., Chicago.

SALESMEN AND AGENCIES

WANTED: Steam specialty man to represent us. Will mail campaign your territory and give full protection on leads furnished for this purpose. Our product is well established in our home territory so that we are now ready to expand. Address K. & M. Steam Engineering Company, 94 Franklin Ave., West Orange, New Jersey.

ESTABLISHED SALES ENGINEERS wanted to sell Flexibrick, a plastic furnace lining and Flexibond, a high temperature cement. Both high quality products. Exclusive territory available. Flexibrick Co., 1435 Greenfield Ave., Milwaukee, Wis.

PLANS for 1930

This is the time of year when all departments of your business are making plans for the coming year.

Several firms in the power plant equipment business now estimate their requirements for space in the Signboard Section for a year in advance and contract for a minimum amount to be used during the year.

By contracting for their space in advance and agreeing to use at least one inch in each issue a lower rate per inch can be secured than would apply if space were ordered from issue to issue.

It is the experience of most advertisers that a program of continuous advertising is far more successful in the long run than hit or miss advertising.

Why not let us assist you in planning your advertising for 1930? Let us explain the flexible contract under which you can order your space in the Signboard Section for the coming year?

Write to

The Signboard Section
Power Plant Engineering
53 W. Jackson Blvd. Chicago, Ill.

SIGNBOARD SECTION

Quick Action Opportunities

EQUIPMENT FOR SALE

EXCEPTIONAL OIL ENGINES

180 H.P. Fairbanks Morse Late VA, Like New.
250 HP. Busch Sulzer, Excellent.
520 HP. Busch Sulzer, Excellent.
750 H.P. Fulton, Like New, used only 110 days.
Full Equipment, with Generators to suit. Exceptional Bargains. Priced to move. These only a sample.
All other sizes available. Get Bulletin 388 listing over 200, or advise what you require.

GASOLINE OR NATURAL GAS ENGINE

1—120 HP. Waukesha, in stock, excellent, will furnish with Heads for either Gasoline or Natural Gas. An unusual Power Unit, all complete on Steel Skids, with Radiator. Was Used Only Short While.

ZELNICKER IN ST. LOUIS

Rails, Equipment, Machinery, Steel Sheet Piling, Boilers, Tanks, etc.
—Oil Engines a Specialty—

PATENT ATTORNEYS

STERLING P. BUCK
PATENT ATTORNEY
Patent Office Register No. 7780.
Ask for
Special quotations to Engineers.
E-629 F St. N. W., Washington, D. C.
Near U. S. Patent Office

PATENTS—Booklet free. Highest references. Best results. Send drawing or model for search and advice. WATSON E. COLEMAN, Registered Patent Lawyer, 724 9th Street, Washington, D. C.

EQUIPMENT FOR SALE

STEAM TURBINES

6—300 hp. Curtis Steam Turbines, Type L 23, 3 stage, 2,000 r.p.m., 150 lbs. steam pressure and 1 lb. back pressure.
4—181 hp. Alberger-Curtis No. 361, single stage Steam Turbines, non-condensing type, 150 lbs. steam pressure, 1½ lbs. back pressure, 1,900 r.p.m.
6—225 hp. Moore, Multi-stage Steam Turbines, non-condensing type, direct connected to reduction gear, ratio 3,600 to 970 r.p.m.

Priced low for quick sale.

Nashville Industrial Corporation
Old Hickory, Tennessee

FOR SALE

1 Balanced valve Ball & Wood Engine, 60 H.P. at 100 lbs. throttle. This is an old engine but in good running order; its use being discontinued on account of electrification of plant. Would be very suitable for sawmill.

Also 1-6KW, 110 Volt; D. C. Generator with switchboard.

Also 1-6 foot and 1-7 foot steel plate low velocity fans suitable for kiln ventilation, etc.

Salisbury Brothers Furniture Co.
27 Salisbury St., Randolph, Vt.

WANTED

Approx. 100 ton refrigerating unit; steam driven; Vilter or Wolf type. State size, age, shop number, location, delivery and price.

ATLAS BREWING CO.
2107 Blue Island Ave., Chicago, Ill.

EQUIPMENT FOR SALE

A. C. UNITS

800 KVA, G. E.—30x48 Allis Chal.
750 KVA, Wghse.—30x34 Ames Uniflow.
625 KVA, Wghse.—Rice Sargent Cross Comp.
600 KVA, G. E.—24x36 Filer Stowell.
600 KVA, G. E.—Hamilton Tandem.
468 KVA, Wghse.—26x32 Skinner Uniflow.
450 KVA, G. E.—28x32 Nordberg Uniflow.
400 KVA, G. E.—22x32 Nordberg Uniflow.
375 KVA, G. E.—22x28 Chuse 4 V.
312 KVA, G. E.—Chuse 4 V.; Cross Comp.
300 KVA, G. E.—20x36 Allis Chal.
250 KVA, Al. Chal.—22x30 Nordberg Uniflow.
250 KVA, G. E. Turbine; up to 40 lbs. back pres.
175 KVA, G. E.—18x22 Harrisburg Uniflow.
150 KVA, G. E.—15x16 Skinner Uniflow.
100 KVA, G. E.—Harrisburg 4 V.

Power Plant Equipment Co., Inc.
39-41 Cortland St., New York City

FOR SALE VERY REASONABLE

1—Geo. F. Blake 8"x7"x10" steam driven Boiler Feed Pump.
1—Geo. F. Blake 7"x5"x9" steam driven Boiler Feed Pump.
1—Ball & Wood High Speed 13"x11" direct connected steam engine and Northern 250 volt—60 K. W.—D. C. Generator.
1—Durham steam driven 16"x8"x18" Vacuum Return Pump.
1—Northern 60 K.W.—230 volt D. C. Generator arranged for Belt Drive with pulley.
1—Northern 50 K. W.—230 volt D. C. Generator arranged for Belt Drive with pulley.
All of the above items in A-1 shape and can be placed into immediate use without reconditioning.

Box 1016
POWER PLANT ENGINEERING
53 W. Jackson Blvd., Chicago, Ill.

Rehabilitation of Power Plants
Capital furnished—Savings on fuel bills guaranteed. Plant owners using five cars or more weekly of Smokeless Coal, or oil, in Illinois, Indiana, Minnesota, Wisconsin, Missouri, Iowa or Michigan, may avail themselves of this opportunity. Address Box 1017, Power Plant Engineering, 53 W. Jackson Blvd., Chicago, Ill., for information, giving annual fuel consumption and location of plant.

Just Off the Press

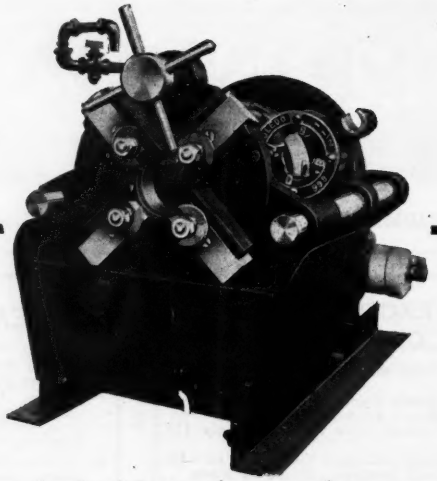
ELECTRICITY—WHAT IT IS AND HOW IT ACTS

A new and highly stimulating book for the electrical engineer, the student of electricity and all engineers who are interested in learning more about this fascinating subject.

This is not an elementary study of electrical engineering. It is not concerned with the solution of practical electrical problems nor is any attempt made to deal with the constructional features of electrical equipment. It is a work which deals with the fundamental principles which underlie the laws upon which electrical engineering is based.

The Price Is $2 per Copy

TECHNICAL PUBLISHING COMPANY **53 West Jackson Blvd., Chicago, Illinois**



BE PREPARED—

FOR YOUR MAINTENANCE WORK

You no doubt remember the last break-down in your plant's piping equipment, where every minute counted and you were provided only with hand tools to handle the work.

If you do, then you know how much you needed a small, compact, light, ½″ to 2″ power machine to handle such jobs efficiently.

The "TOLEDO" No. 999 can be used anywhere about the plant. Plug into a lamp socket, switch on the current and cut and thread pipe 10 times as fast as by hand.

Here's the pipe machine you need. The most efficient machine you can add to your equipment. Send us a post card for complete information.

THE TOLEDO PIPE THREADING MACHINE CO., TOLEDO, OHIO

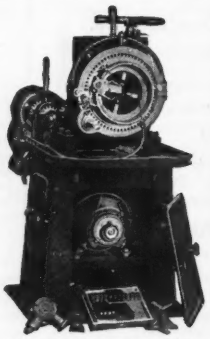
"TOLEDO"

A "TOLEDO" NO. 999 WILL SOON PAY FOR ITSELF

Curtis

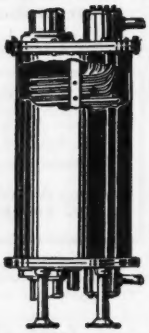
—the accurate and time-saving Pipe Cutting and Threading Machine for the modern plant.

The Curtis & Curtis Co.
189 Garden St.
Bridgeport, Conn.



No. 258 Range, 1 to 6 in. R. H., Direct - Connected Electric

Built For Long Service and Greatest Efficiency



There is a decided advantage offered to the user of well-designed and built National

Feed Water Heaters
Heat Exchangers
Air Coolers Oil Coolers

Backed by 45 years of manufacturing high-grade equipment. Each job individually engineered. Write for descriptive bulletins.

The National Pipe Bending Co.
Est. 1883
160 River St., New Haven, Conn.
Boston New York Philadelphia

IMMEDIATE BOILER TUBE SERVICE

Straight and Bent Tubes for all Types of Boilers

WRITE FOR QUOTATIONS

BOILER TUBE COMPANY OF AMERICA

3126 PREBLE AVE., PITTSBURGH, PA.
CHICAGO NEW YORK

Storage Batteries

By Morton Arendt.

Complete treatment of principles of action of batteries, details of construction and of care, operation and maintenance. Written specially for the man in charge of the plant to insure satisfactory service. 285 pp. Fully illustrated. Price $4.50.

POWER PLANT ENGINEERING
53 W. Jackson Blvd., Chicago, Ill.

The thing to REMEMBER when buying

INSULATION

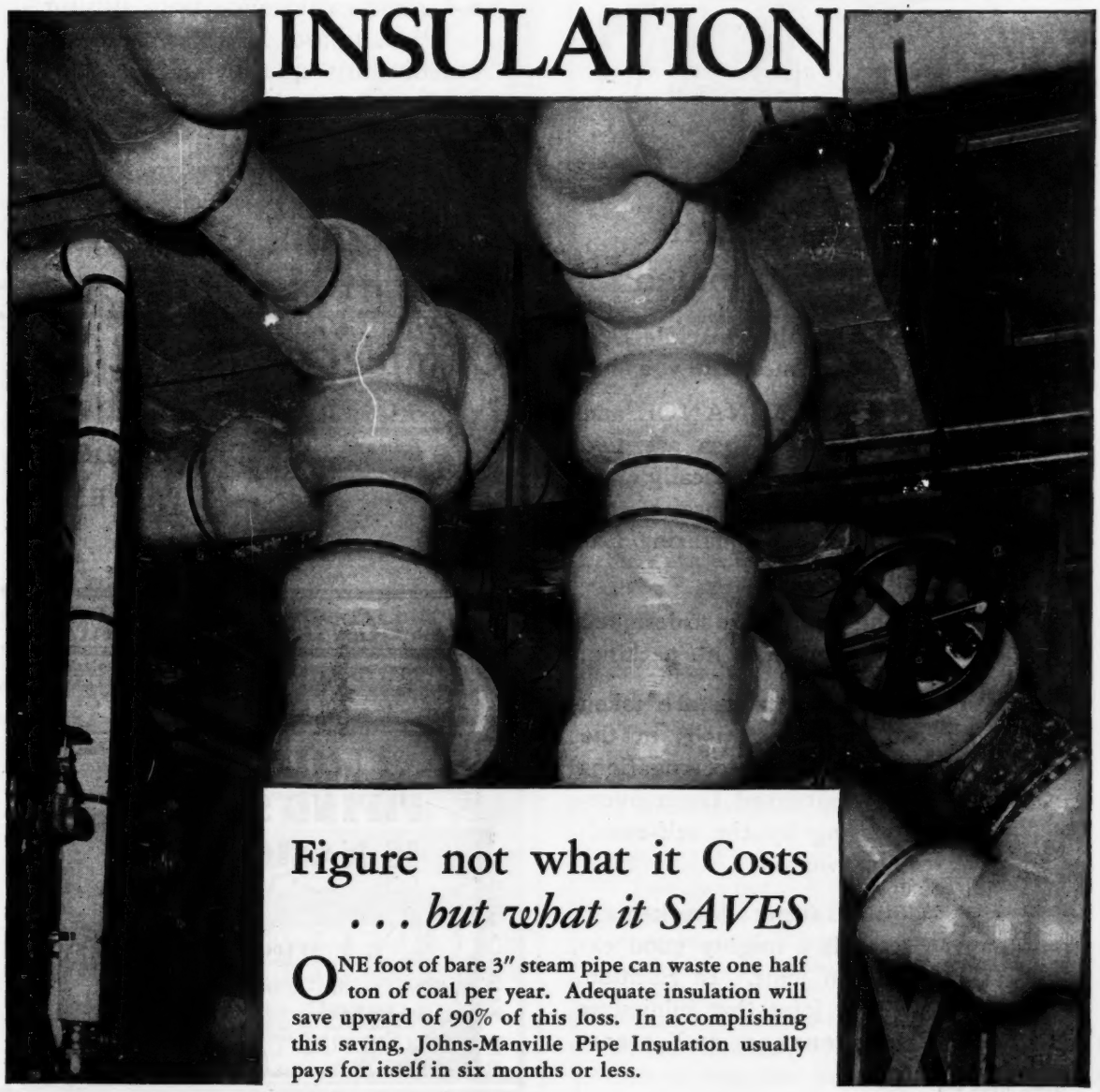


Figure not what it Costs *. . . but what it SAVES*

ONE foot of bare 3" steam pipe can waste one half ton of coal per year. Adequate insulation will save upward of 90% of this loss. In accomplishing this saving, Johns-Manville Pipe Insulation usually pays for itself in six months or less.

Adequate insulation saves money and increases efficiency in one of the most important units in any organization—the power plant. Your boiler settings, hot and cold water lines, stacks and breechings, evaporators and refrigeration apparatus all offer opportunities for saving by proper insulation.

The function of our engineers is to show you where the right kind of insulation can be applied to save you far more money than it will cost.

If you are still skeptical as to the economy value of insulation call in a Johns-Manville expert. His advice costs you nothing. He will make an insulation survey of your plant and point out to you definitely where insulation can be *economically* applied. He represents the largest technical organization in the world specializing on insulation of all kinds . . . for every application. Sixty Branches conveniently located assure prompt service.

Coupon is attached for your convenience.

JM

Johns-Manville
INDUSTRIAL INSULATIONS

For all temperatures from 400° F. below zero to the highest industrial temperatures

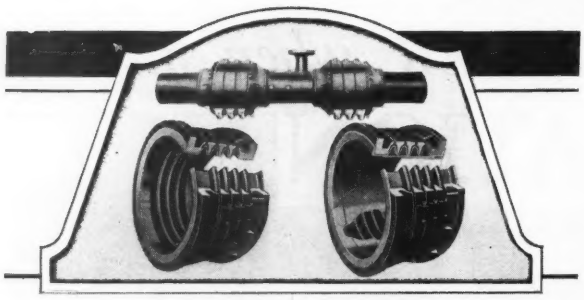
JOHNS-MANVILLE CORPORATION
New York, Chicago, Cleveland, San Francisco, Toronto
(Branches in all large cities)

I am interested in knowing how J-M Insulations might save money in our plant. Please have a J-M Insulation Engineer call.

*Name*_____

1-50-12

*Address*_____



Maintenance and Steam-loss Eliminated

—what this "pack-less" joint means to you

MAINTENANCE and steam-loss are two cost factors practically eliminated by the use of the Badger Self-Equalizing Expansion Joint.

Badger Joints are so designed that they need no packing.

Line movements are taken up by corrugations in the copper. These corrugations are protected from overstressing by the self-equalizing rings.

If compactness is the most pressing need in your plant, you will be interested to know that, size for size, Badger Self-Equalizing Expansion Joints have the smallest overall outside diameter of any joint.

The Badger "Pack-less" Joint is a mighty good expansion joint. In addition, it is a joint that minimizes maintenance and steam losses.

Specify the Badger Joint for your lines.

E. B. BADGER & SONS COMPANY
71 Pitts St., Boston, Mass.

New York, N. Y., 271 Madison Ave.
Syracuse, N. Y., 404 S. Clinton St.
Minneapolis, Minn., 716 Builders Exchange
Charlotte, N. C., 1408 Realty Bldg.
Denver, Colo., 414 W. Colfax Ave.
Chicago, Ill., 2831 S. Parkway
Cleveland, Ohio, Guardian Bldg.
Cincinnati, Ohio, Union Trust Bldg.
Atlanta, Ga., Red Rock Bldg.
Salt Lake City, Utah, Kearns Bldg.
Philadelphia, Pa., 1500 Walnut St.
Detroit, Mich., 1728 Ford Bldg.
St. Louis, Mo., 3605 Laclede Ave.
Houston, Texas, 1308 Second Nat. Bank Bldg.
San Francisco, Cal., Sharon Bldg.
Pittsburgh, Pa., Union Trust Bldg.
Montreal, Quebec, Canada Cement Bldg
Los Angeles, Cal., 517 Hollingsworth Bldg.
Portland, Ore., 1000 Buyers Bldg.
Seattle, Wash., 415 Lenora St.

SEVENTY-FIVE years' intimate experience with piping in all its phases is responsible for outstanding quality of Grinnell fabricating service.

Address inquiries to Providence, R. I.

GRINNELL COMPANY

Complete Power Piping

CAST STEEL FITTINGS
WELDED HEADERS
PIPE BENDS

Geo B LIMBERT PIPING & Co
570 FULTON STREET CHICAGO, ILLINOIS

PIPE FABRICATION & ERECTION

MIDWEST PIPING SERVICE IS NATION-WIDE

MIDWEST PIPING & SUPPLY CO., Inc
Main Office: St. Louis

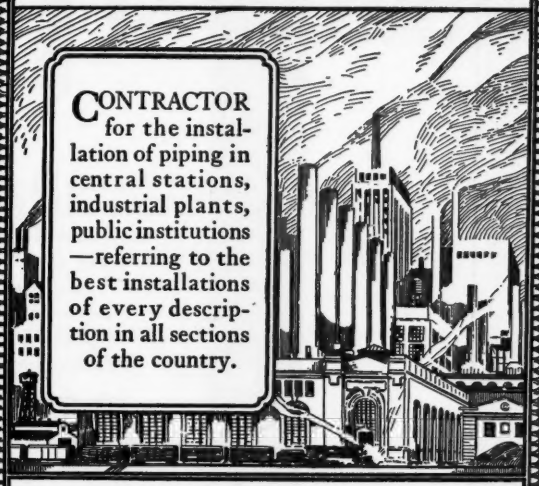
INDUSTRIAL PIPING

Power Piping Co., Pittsburgh, Pa.

Power Piping
FOR EVERY INDUSTRIAL NEED

PIPING CONTRACTOR

CONTRACTOR for the installation of piping in central stations, industrial plants, public institutions—referring to the best installations of every description in all sections of the country.



WILLIAM A. POPE

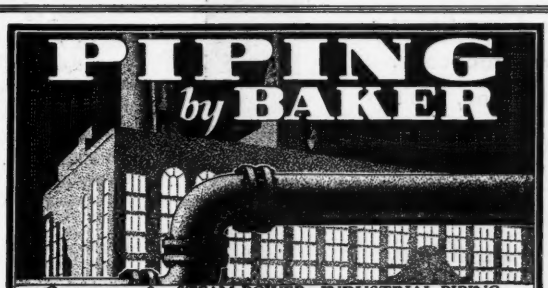
Associates

WILLIAM H. MILLER R. A. WIDDICOMBE
S. AUSTIN POPE

26 North Jefferson Street, Chicago

Licensee: Sargol Joints (Patented)

PIPING by BAKER



Contractors for STEAM POWER - INDUSTRIAL PIPING

R. H. BAKER COMPANY
INCORPORATED

General Motors Bldg. Detroit Mich. CAMBRIDGE, MASS 101 Park Avenue New York City

SEND FOR PORTFOLIO ILLUSTRATING OUR SERVICE

Pittsburgh Piping

MANUFACTURERS AND CONTRACTORS

WHEN YOU THINK OF PIPING THINK OF PITTSBURGH PIPING P&E CO.

WE ARE fully equipped to supply fabricated materials and to install complete piping systems for Electric Power Stations, Blast Furnaces, Steel Mills, Coke Works and Industrial Plants of every description—backed by an experience of more than a quarter century.

PITTSBURGH PIPING & EQUIPMENT CO.
43rd St. and A. V. R. R., Pittsburgh, Pa.

New York 220 Broadway — Chicago Peoples Gas Bldg. — San Francisco Russ Bldg. — Cleveland Ulmer Bldg.
Houghton, Mich. — Indianapolis — Detroit
Dee Bldg. — Traction Terminal Bldg. — General Motors Bldg.
Boston, 10 High St. — Dallas, Texas, Am. Ex. Bk. Bldg.
Los Angeles, Bartlett Bldg.

A $450.00 EXTRA DIVIDEND
For One Ric-wiL User *this Winter*

Note how fully engineered Ric-wiL Conduit is: the flat-bottom base drain that supports the tile conduit, increasing its strength fully 35%; the independent pipe supports; the Loc-liP side joint that reseals the tile split for easy installation.

BESIDES the normal dividend a good central heating system pays out of profits that come from lower coal and labor bills reduced fixed charges and other economies, owners of steam distribution lines in Ric-wiL Conduit will receive an extra dividend this winter.

It will come to them directly out of the **extra efficiency** of Ric-wiL, efficiency over and above the guaranteed 90%, out of the Ric-wiL ability to hold heat losses from 2% to 5% lower than can be expected from ordinary conduits.

As an indication of what this means, take the case of one customer in New York who has a 2400 ft. run of steam line insulated with Dry-paC in Ric-wiL Conduit. On the basis of an actual test of efficiency, the extra over 90% saving to the owner will amount to $450.00 per year.

Test after test of Ric-wiL installations of all kinds, various lengths of runs, different sizes of steam pipes, different ground and weather conditions, are showing this extra-dividend efficiency.

The cause is clear: Ric-wiL is an underground insulating system unusually well drained, strong and watertight, with the extraordinary Dry-paC insulation in closed construction to guarantee its permanent dry efficiency.

By all means, investigate this extra-dividend conduit for your next job.

The Ric-wiL Company
1564 Union Trust Bldg., Cleveland, O.
New York—Boston—Baltimore—Atlanta—Chicago

Originators of Waterproof Conduit Fillers
RIC-WIL
UNDERGROUND CONDUIT

Showing installation of Reading Charcoal Iron Boiler Tubes (Scotch Marine Type) in the boilers of the Southern Pacific Steamship Company's *S. S. El Occidente*

TO know the truth about boiler tubes, look into their past—the record of known savings effected through their use. With Reading Charcoal Iron Boiler Tubes, you will find this record stretching back for generations—countless installations in every class of service where Reading Charcoal Iron Boiler Tubes have meant greater economy! What better proof could there be that Reading Tubes will save money for you, too?

The inherent structure of Genuine Charcoal Iron resists corrosion and metal "fatigue". That is why Reading Tubes last several times longer than ordinary tubes. The stencilled name "Reading" guarantees that you get Genuine Charcoal Iron.

READING IRON COMPANY, Reading, Pennsylvania

Atlanta · Baltimore · Cleveland · New York · Philadelphia · Boston
Cincinnati · St. Louis · Chicago · New Orleans · Buffalo
Houston · Tulsa · Seattle · San Francisco · Detroit
Pittsburgh · Ft. Worth · Los Angeles · Kansas City

Reading Charcoal Iron Boiler Tubes are furnished in sizes ranging from 1½" to 6" in diameter and may be obtained through the following distributors:

John McKenzie and Co.
Baltimore, Maryland

Williams and Co.
Cincinnati, Ohio

Williams and Co.
Cleveland, Ohio

Harrisburg Pipe & Pipe Bending Co.
Houston, Texas

Standard Supply & Hardware Co.
New Orleans, La.

John B. Astell and Co.
New York, N. Y.

Eagleston Parke, Inc.
Norfolk, Va.

John B. Astell and Co.
Philadelphia, Pa.

Williams and Co.
Pittsburgh, Pa.

A. M. Castle & Co.
Chicago, Seattle, San Francisco and Los Angeles

Pidgeon-Thomas Iron Company
Memphis, Tenn.

Export Agents,
Wonham, Inc.
New York City

READING PIPE
CHARCOAL IRON BOILER TUBES

TIME *has told its story* of PIPE *for* POWER

FOR MORE than half a century, NATIONAL Pipe has been building an enviable record for power plant dependability. As the service requirements have become more and more severe—as the super-service systems for gigantic installations have been developed—as pressures and temperatures have continued to mount—NATIONAL Pipe has set the standard for unfaltering performance—the pacemaker in pipe dependability which has made possible these marvelous developments.

Strength, uniformity, ductility, sound welds, strong threads, clean smooth surfaces and resistance to corrosion are some of the NATIONAL Pipe advantages which appeal to modern power plant engineers and account for its very extensive use today. Available in all sizes, for any pressures, for any type of joint and for all kinds of bending and forming purposes.

Write for Bulletin No. 10, describing NATIONAL Pipe—

Standard of America's Power Plants

NATIONAL TUBE COMPANY

Frick Building, Pittsburgh, Pa.

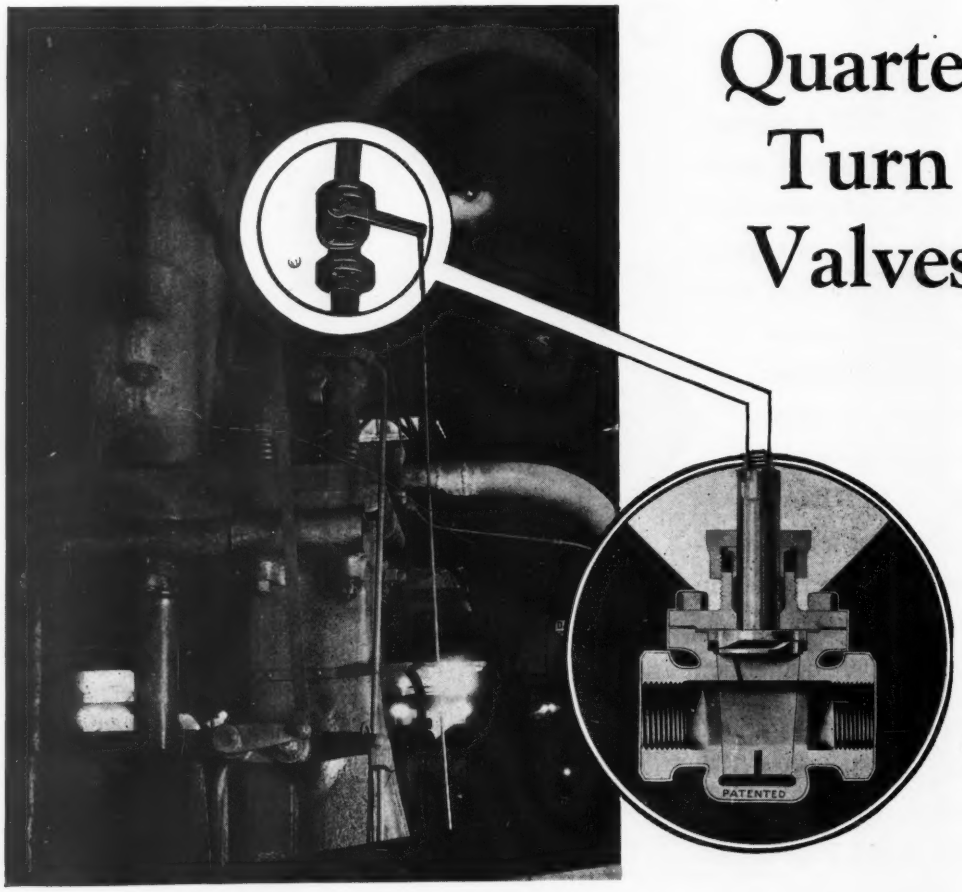
SUBSIDIARY OF UNITED STATES STEEL CORPORATION

PRINCIPAL SUBSIDIARY MANUFACTURING COMPANIES:

AMERICAN BRIDGE COMPANY
AMERICAN SHEET AND TIN PLATE COMPANY
AMERICAN STEEL AND WIRE COMPANY
CARNEGIE STEEL COMPANY
CYCLONE FENCE COMPANY
FEDERAL SHIPBUILDING AND DRY DOCK COMPANY
ILLINOIS STEEL COMPANY
MINNESOTA STEEL COMPANY
NATIONAL TUBE COMPANY
THE LORAIN STEEL COMPANY
TENNESSEE COAL, IRON & R. R. COMPANY
UNIVERSAL PORTLAND CEMENT COMPANY

Pacific Coast Distributors—United States Steel Products Company, San Francisco, Los Angeles, Portland, Seattle, Honolulu. *Export Distributors*—United States Steel Products Company, New York City

HOMESTEAD



Quarter Turn Valves

in Steam Hammer Service

Here is a type of service that requires a quick acting, full opening and rapid closing valve. One that will stand up under severe service—that will open and close a hundred times a day and not leak.

The Homestead Quarter Turn Valve shown has been giving full satisfaction in steam hammer service for the Studebaker Corpn. This valve paid for itself in two months in savings effected thru the elimination of a heavy steam loss.

Whether your service is steam hammer or some other equally severe condition, Homestead Quarter Turn Valves will meet your requirements. This husky valve is carefully made—plugs are ground and fitted—and thoroughly tested before passed to stock.

If you want trouble-free valve operation, and lower maintenance, you should investigate Homestead Quarter Turn Valves. There's one for your service.

Catalog or representative? Write for appointment—there's a dealer near you.

THE HOMESTEAD VALVE MANUFACTURING CO., P. O. Box H, Coraopolis, Penn.

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QUARTER TURN VALVES:
STRAIGHT WAY
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LUBRICATED TYPE
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PROTECTED SEAT VALVES:
HYDRAULIC (B & O. PAT.) OPERATING
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ROSS AIR SHUT-OFF VALVE
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ALWAYS IDENTIFIED..... Every Jenkins Valve . . . whether of bronze or iron . . . is marked with the Jenkins "Diamond" trade mark, cast in relief on the valve body above the signature "Jenkins Bros". This ever-present symbol is more than a mere identification. It is a guide that valve buyers have come to follow confidently, knowing that the installation of Jenkins leads to valve efficiency and economy over a long period of years. Supply houses everywhere can furnish Jenkins Valves in standard, medium and extra heavy. Jenkins Bros., New York, Boston, Philadelphia, Chicago . . . Jenkins Bros., Ltd., Montreal, London. (*Standard Bronze Gate Valve.)

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VALVES
Since 1864

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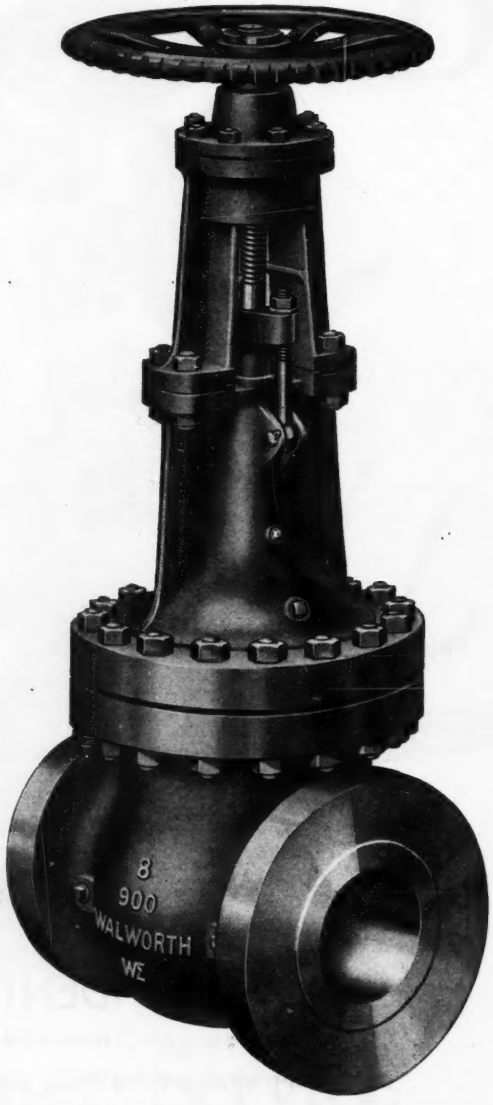

Walworth Sigma Steel Series 900

Walworth Sigma Steel Catalogue tells all the facts about Walworth Sigma Steel. It is yours for the asking. Walworth Sigma Steel Valves and Fittings are now available in Series 150, 300, 400, 600, 900 and 1350.

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Mountings can be furnished in Stainless Steel, Monel or Bronze . . . according to the service required . . . and are fully guaranteed for that service.

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We gladly give you 2 *if one ever fails!*

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Two unions for one if one ever fails is our standing guarantee placed back of every Dart Union. The fact that Dart Unions do NOT fail is the main feature that counts in power plant economy.

Dart Unions are leak-proof. The bronze-to-bronze seats prevent corrosion. The malleable iron body holds against all pipe line stresses.

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Know the complete line of Dart Unions and Union Fittings and why they are generally specified throughout leading plants.

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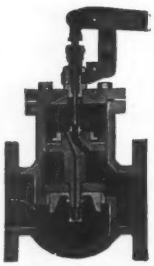
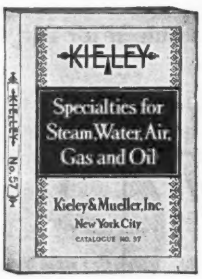
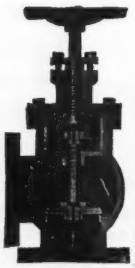

Float Valve

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for Steam, Water, Air and Gas

With Kieleys you can be sure of results. This line of specialties which has developed during the experience of 50 years, is the latest thing in efficiency.

Shown here are the Stop and Check Valve, constructed and designed to prevent sticking and pounding, and the Float Valve, designed to close tight regardless of pressure on inlet side. All specialties constructed with best of materials including Monel Metal for higher temperatures.

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Hot Forged Steel Unions

—Masters of the Highest Temperatures and Pressures in Modern Plants

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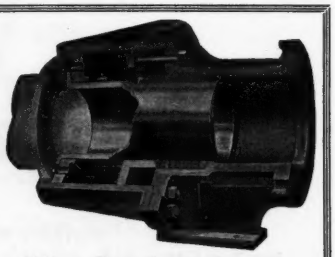

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Eliminates trouble from Expansion and Contraction, saves space, labor and repair bills; the construction is mechanically correct.

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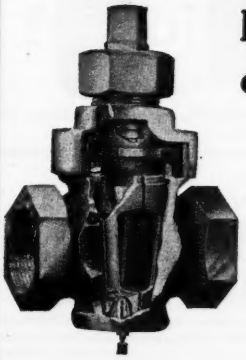
A Superior Speed Reducer for Isolated Drives

This 45 to 1 ratio gear transmits 10 hp. from a 1160 r.p.m. motor to an inclined bucket elevator. It is connected to the driving motor and to the driven machine by DeLaval Flexible Couplings. Inspection of the oil level at long intervals is the only attention required.

De Laval Steam Turbine Co., Trenton, N. J.

Chart shows correct lubricant to use on each service



Cadman Lubricated "Gato" Valve

Careful scientific study and long use determined the correct lubricants to be used on each of the various industrial services on which this valve is proving its value. As it is constructed with the original "Gato" features, it seats tight and never binds or sticks without lubricant. Therefore the lubricant is designed only for protection of internal parts against action of media that passes through the valve. Less lubricant and a more perfect one for each service is thus assured. Write.

BARRETT MACHINE COMPANY
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Also Mosher Separators, "Indestructible" Blow-Off Valves and Gauge Cocks
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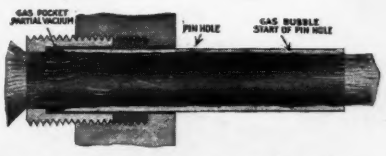
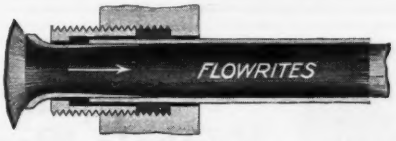
Remarkable Savings in condenser tube renewals



BEFORE FLOWRITE—illustrated above, see how the pocket at the end of the condenser tube collects gas, resulting in constant corrosive action, and pin holes that quickly ruin the whole tube end.



AFTER FLOWRITE—condenser tube end has no pockets where corrosion can start. Flow is smoothly directed so less power is required, erosion eliminated and pin holes ended.

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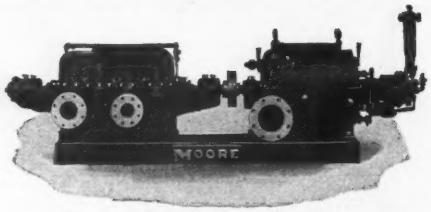
BOILER FEED UNITS



Moore Four-Stage Boiler Feed Pump
Driven by
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Undivided responsibility.
Co-operation of turbine and pump engineers to produce best unit.
Built to Steam Turbine standards throughout.
Unit includes pump governor.
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JENNINGS Sewage Ejectors afford an efficient unit for pumping unscreened sewage and drainage from buildings where toilets or drain pipes are below street sewer level. Automatically controlled, pneumatic in operation; they are odorless and compact enough to be installed where space is limited.

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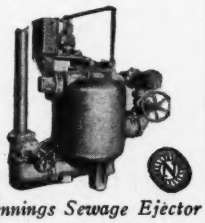

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NASH ENGINEERING CO.
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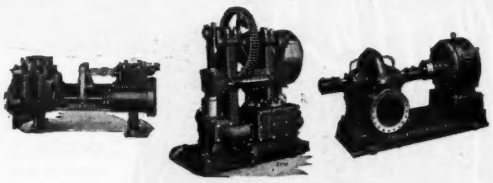

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"Platt" and "Smith-Vaile" Pumps
Steam and Power Pumping Machinery

THE MULTI-BOND CHROME ORE CEMENT
Shipped DRY in Steel Containers, 200 lbs. Net Weight

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Coppus Manhole Blower

for cooling and ventilating boilers, tanks, etc.—easily hooked up to manhole.

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a universal man cooling fan of unequalled efficiency.

118 lbs.

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COMPACT
RUGGED
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5 to 250 GPM
Heads up to
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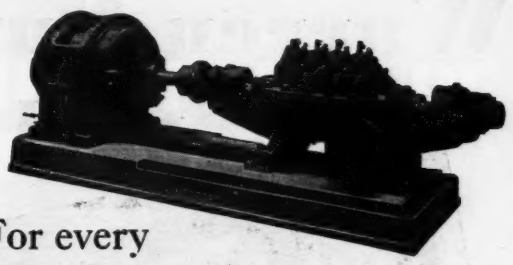
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for oils—light or heavy, hot or cold
High speed, direct connected.
7 standard sizes. Capacities ½ to 150 g.p.m.
Pressures up to 250 lbs.
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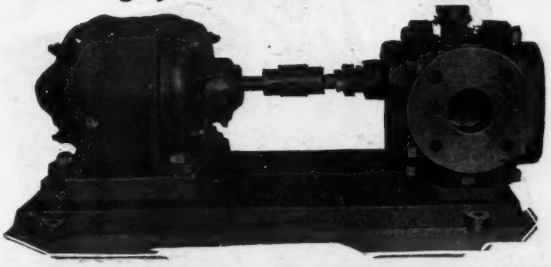
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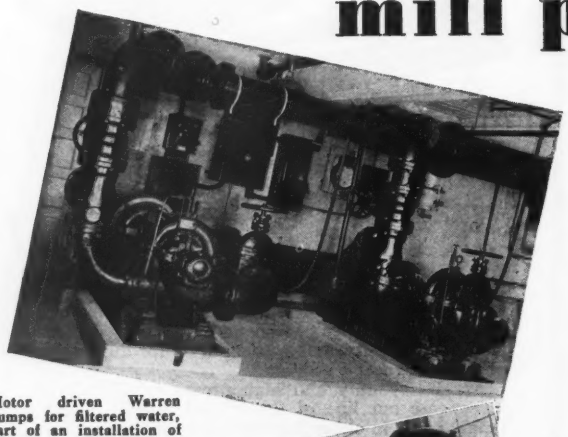
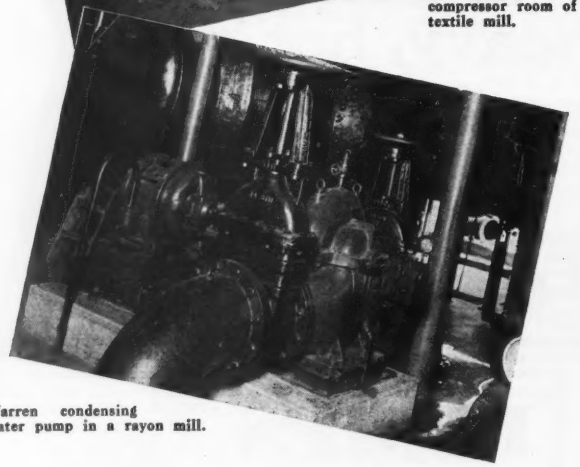
Warren Pumps cut textile mill pumping costs



Motor driven Warren Pumps for filtered water, part of an installation of 21 Warren Pumps in a rayon mill.

Warren Pumps in the compressor room of a textile mill.

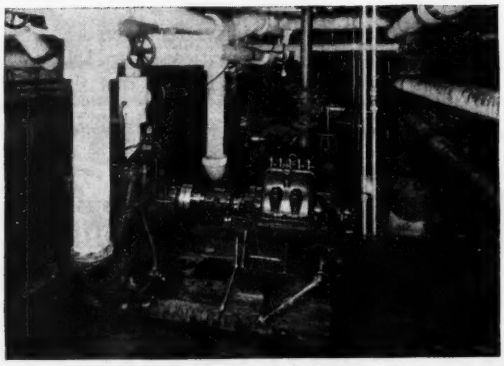


Warren condensing water pump in a rayon mill.

Textile mills are large users, careful buyers of pumps; spare no effort to obtain equipment which will deliver the lowest possible pumping cost per year.

Chosen because of their efficient, economical operation, low maintenance and dependable performance, Warren Pumps are installed in an increasing number of textile mills each year.

Improvements in design and construction not found in ordinary pumps and complete specifications are completely described and illustrated in Bulletins. Write for copies covering the services in which you are interested.



Two Warren boiler feed pumps in a woolen and worsted mill.

Warren

Steam Pump Company Inc. — **Warren Massachusetts**

Agencies in all principal cities.

3332

THE DAY OF THE HIGH PRESSURE STEAM PLANT IS HERE

It is significant that Cameron Boiler Feed Pumps will be used in each of these great central stations.

INGERSOLL-RAND COMPANY
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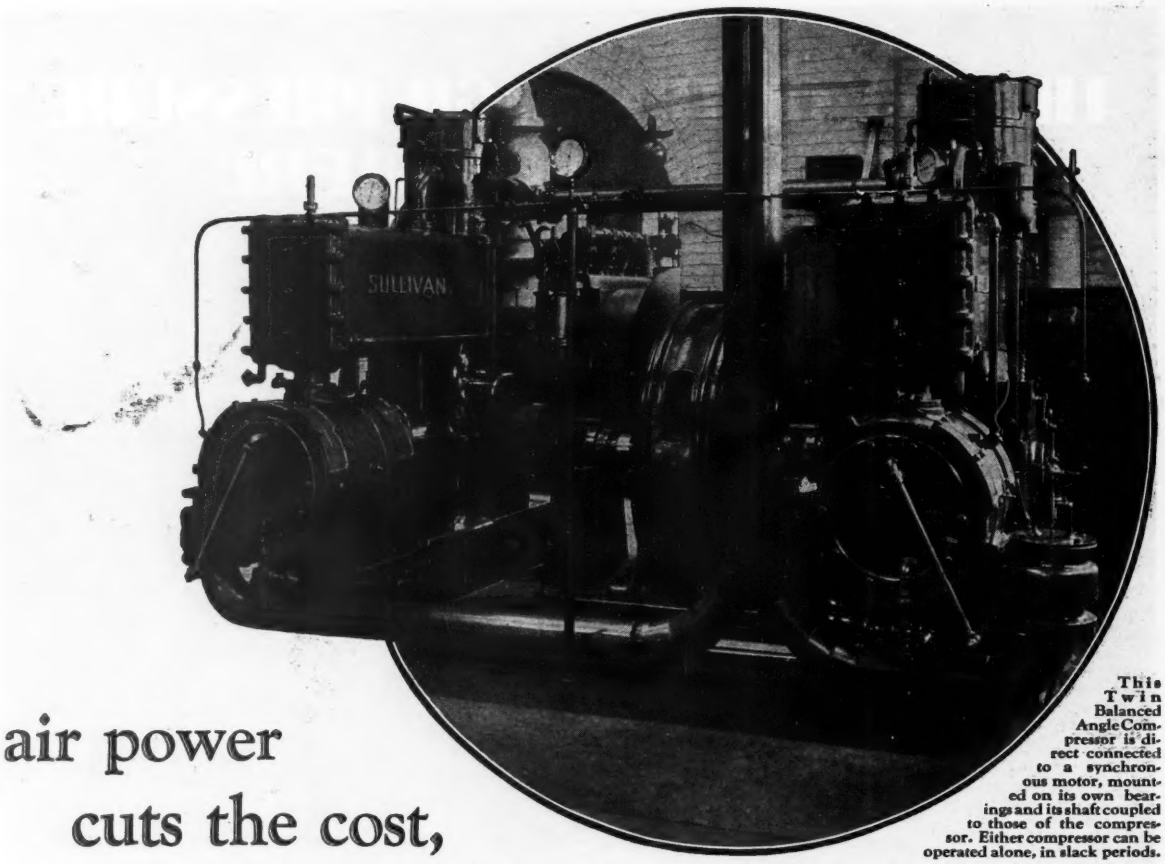
A. S. Cameron Steam Pump Works

372-DV

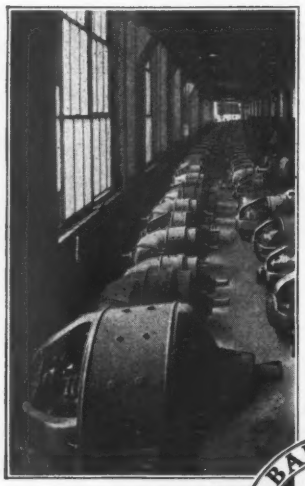
Ingersoll-Rand



This Twin Balanced Angle Compressor is direct connected to a synchronous motor, mounted on its own bearings and its shaft coupled to those of the compressor. Either compressor can be operated alone, in slack periods.

air power cuts the cost, and electricity serves new millions

Balanced Angle Compressors increase profits for Builders of ⅔ of America's electrical equipment



A cost cut on an electrical product may bring a million customers. A million new buyers in industry—or a million new families who wash, iron, sew, clean, refrigerate, or exercise, electrically.

Production processes and machines set the growth of the electrical industry. They are adopted, when they prove they can cut costs.

—and today, builders of two-thirds of America's electrical equipment use air power from Balanced Angle Air Compressors.

In the plant illustrated, two twin Balanced Angle Compressors were bought first. Then a third, a fourth, a fifth, followed in quick succession.

While air proved its economy on a swiftly-growing list of uses—Balanced Angle Compressors proved their economy in power, maintenance, and floor space.

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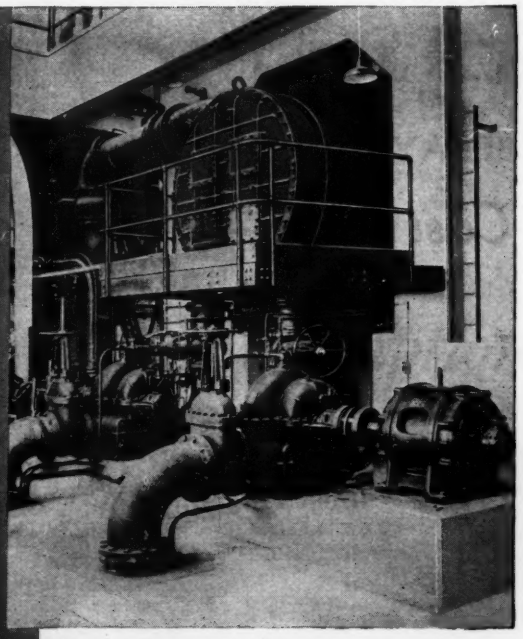
Modern Condensers

WESTINGHOUSE ELECTRIC & MFG. COMPANY
SOUTH PHILADELPHIA WORKS PHILADELPHIA, PA
SALES OFFICES AND SERVICE SHOPS IN ALL PRINCIPAL CITIES



Features of Westinghouse small surface condensers:

A LARGE steam dome extending over the tube bank for the full length and width of the shell gives excellent steam distribution which is so necessary for high condenser efficiency.

The liberal tube spacing and short travel of steam through the tube bank reduce friction loss to a minimum.

The tube arrangement is such that a minimum temperature difference is maintained between the incoming steam and the condensate.

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Westinghouse

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Equipment for power plants includes:

Air Ejectors
Circuit-breakers
Feed Water Heaters
Generators
Generator Air Coolers
Heat Exchangers
Instruments
Insulators
Jet and Barometric Condensers
Meters
Motors
Reduction Gears
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Switchboards
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SPRAY COOLING SYSTEMS

Cost Less—

to Install
to Operate
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For full information on spray cooling systems write for Bulletin 4-E. No charge—no obligation.

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One of our 2500 installations.

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INVOLUTE SPRAY NOZZLE

Long throat Type B, with removable non-clogging conical orifice.

Yarway-equipped Spray Ponds with a total capacity of more than one and one-half million gallons per minute are operating in 43 States.

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Spray Cooling Equipment

EFFECTS

BIG ECONOMIES

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Spray Pond Operation

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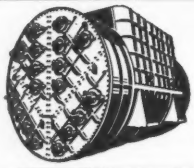
The Marley Company
1737 Walnut St., Kansas City, Mo.



Surface Condensers, Jet Condensers, Barometric Condensers, Leach Fracto Control Condensers, Oil Vapor Condensers for High Vacuum Distillation, Heat Exchangers, Sand Separators, Radojet Air Pumps for vacua up to 29.95 inches, Forced and Natural Draft Cooling Towers.

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Evaporators—Feed Water Heaters—Extraction Steam Heaters—Generator Air Coolers—Lubricating Oil Coolers
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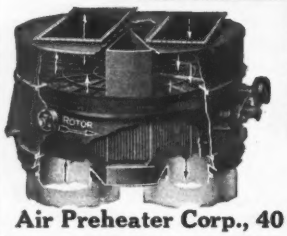

FOR preheating combustion air with heat from the boiler flue gases. 10 to 15 per cent fuel saving. Better combustion from any fuel. 70 per cent heat recovery possible only with the continuous regenerative counterflow principle used exclusively in the Ljungström Air Preheater.

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800,000 Boiler hp. in service in the U. S. A.

Air Preheater Corp., 40 E. 34th St., New York

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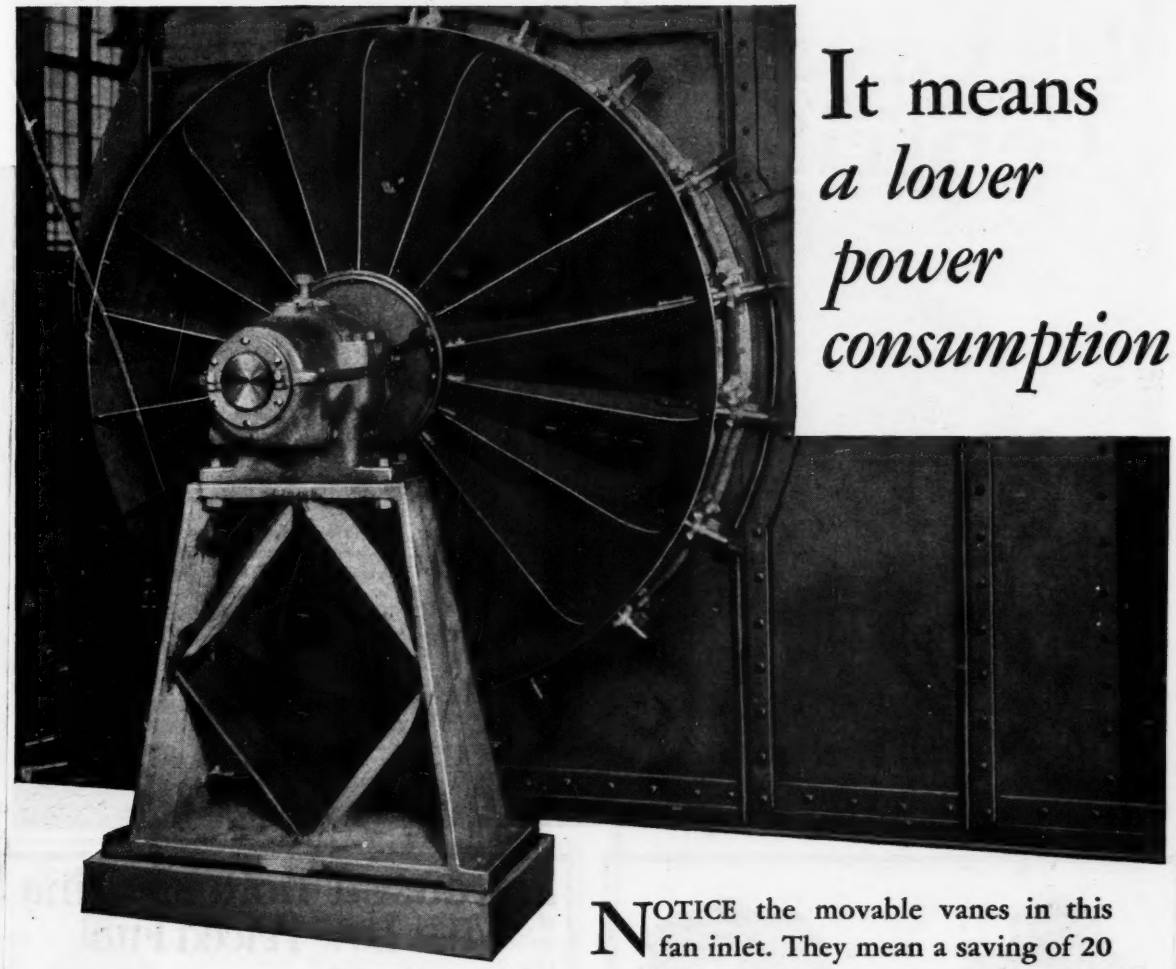
Storage Water HEATERS

with Steam Coils and Thermal Controls

Self-contained with Hoppes multi-trough shape pans, automatic regulating valve, baffle plate oil separator, large hot-water storage capacity. Furnished with or without steam coil, especially adapted to Laundry, Bleachery or Textile industries, many other types, both Vertical and Horizontal, for all purposes. New catalog Number 90.

THE HOPPES MANUFACTURING CO., 70 Larch St., Springfield, O.



It means *a lower power consumption*

NOTICE the movable vanes in this fan inlet. They mean a saving of 20 to 30 per cent in motor input over ordinary damper regulation, and large savings over slip-ring motor control. Control of air pressure and volume becomes *automatic* with constant speed motors.

The Sturtevant Vane Control has been quickly accepted by the prominent stations from coast to coast. It would be a pleasure to send you complete information on Sturtevant Vane Controlled F. D. and I. D. Fans. Please address our nearest Branch Office.

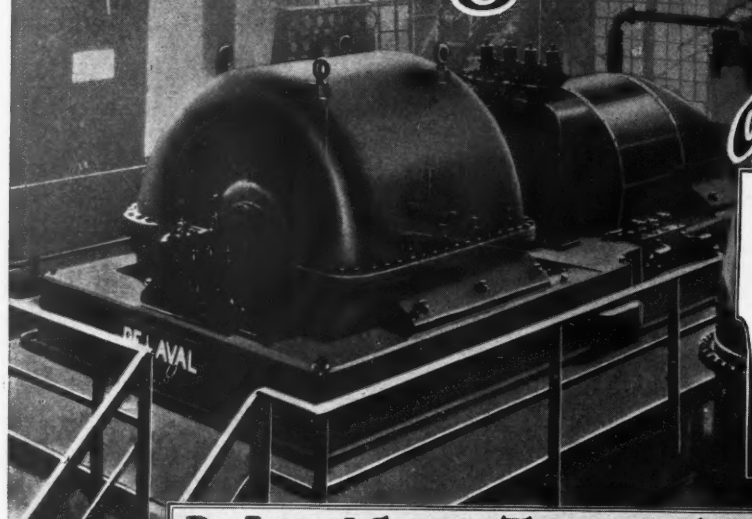
B. F. STURTEVANT CO.
Hyde Park, BOSTON, MASS.

Plants at: Berkeley, Cal. ∿ Camden, N.J. ∿ Framingham, Mass. ∿ Galt, Ontario ∿ Hyde Park, Mass. ∿ Sturtevant, Wis. ∿ *Canadian Representative:* Kipp Kelly, Ltd., Winnipeg. *Offices in Principal Cities.*

Sturtevant REG. U.S. PAT. OFF. *Forced Draft Induced Draft* **FANS**

STEAM TURBINES ~ FORCED AND INDUCED DRAFT FANS ~ ELECTRIC MOTORS
FUEL ECONOMIZERS ~ GENERATING SETS ~ AIR PREHEATERS

De Laval Turbine Driven Centrifugal Blowers are dependable



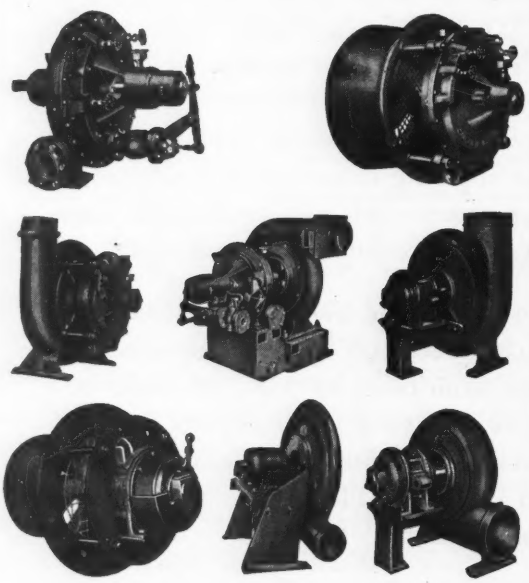
THIS DE LAVAL blast furnace blower delivers 60,000 cu. ft. of air per min. against 30 lbs. per sq. in. pressure when running at 2800 r.p.m. Extremely close regulation is provided by the constant volume governor.

Due to their heavy, rugged construction, low peripheral and rotative speeds, and large internal clearances, De Laval blowers are reliable in operation and the upkeep expense is reduced to a minimum.

Write for Catalog F.

De Laval Steam Turbine Co., Trenton, N. J.

Manufacturers of Steam Turbines, Centrifugal Pumps, Centrifugal Blowers and Compressors, Double Helical Speed Reducing Gears, Worm Reduction Gears, Hydraulic Turbines, Flexible Couplings and Special Centrifugal Machinery

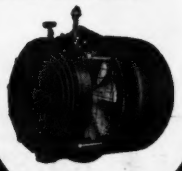


BLOWERS AND TURBINES

CARLING TURBINE BLOWER CO.
WORCESTER, MASS.

Increased Boiler Rating With Low Priced Fuel

A result of Coppus Forced Draft Blowers



DO NOT CHANGE YOUR CHIMNEY OR PUT IN ANOTHER BOILER BEFORE READING BOOKLET NO. 145.

FORCED DRAFT • BLOWER •

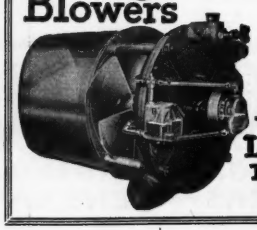
REGISTERED COPPUS U.S. PAT. OFFICE ENGINEERING CORPORATION
340 PARK AVE. WORCESTER, MASS.

CENTRIFUGAL TURBO BOILER FEED PUMPS • STEAM TURBINES • MINE VENTILATING BLOWERS

PEAKS CARRIED EASILY

With a Wing Blower you can meet all peaks and sudden steam demands quickly. Easily installed in the boiler wall of any type boiler. Wing Blowers assure sufficient steam at all times, and often save the purchase of new equipment.

Wing Blowers



Ask for Bulletin 87

L. J. Wing Mfg. Co.
156 West 14th St.
New York, N. Y.

AMERICAN
Chimneys — Boiler Settings

Just another of the many installations where correct engineering and permanent construction were required, is this American Chimney at the Pennsylvania Hospital, Philadelphia, illustrated here. This brick chimney is 150 ft. high and 6 ft. in diameter at the top. Settings of the three Edge Moor boilers in this plant were built by us.

No cost, no obligation, to consult us freely.

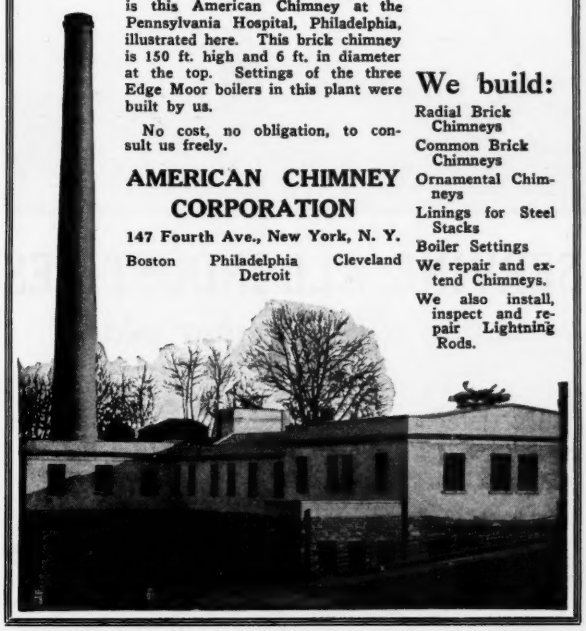
AMERICAN CHIMNEY CORPORATION

147 Fourth Ave., New York, N. Y.

Boston Philadelphia Cleveland Detroit

We build:

- Radial Brick Chimneys
- Common Brick Chimneys
- Ornamental Chimneys
- Linings for Steel Stacks
- Boiler Settings
- We repair and extend Chimneys.
- We also install, inspect and repair Lightning Rods.



FAULKNER'S *Improved* BOND

has been used to lay up fire bricks in entire installation of 52,000 hp. of boilers and proved successful in every job over a period of four years. There are no sodium silicate, chrome ore, or other ingredients in Faulkner's Improved Bond that tend to change the general characteristics or co-efficient of expansion and contraction from that of fire bricks.

This bond holds joints tight through all temperatures up to 3150 deg. F. without disintegration. Price about one-half that of high temperature cements.

The J. A. Faulkner Refractories Co. 523 W. Federal St. Youngstown, Ohio

HIGH TEMPERATURE CEMENTS

FIREBOND THERMOLITH

—REFRACTORIES—

FIRE CLAY HIGH ALUMINA SILICA

CHROME AND MAGNESITE

ACID-PROOF BRICK

HARBISON-WALKER
REFRACTORIES COMPANY

WORLD'S LARGEST PRODUCER OF REFRACTORIES

PITTSBURGH, PA.

Brown invests $1,200 *while* Smith spends $30,000

THERE is an important difference between investing and spending.

Engineer Smith, for instance, is the sort of fellow who always wants a NEW boiler as soon as something goes wrong with the old one. He is a believer in having everything new. The fact that a new boiler costs the owner $30,000 makes no difference to him. Engineer Smith is a "spender."

On the other hand, Engineer Brown is an "investor." He knows the value of money. He knows that if he can show a good profit for the owner his own chances for better remuneration are improved. So instead of shouting for a new boiler as soon as the old one becomes inefficient he studies the situation and asks the owner to *invest* $1,200 in

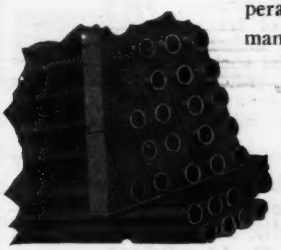
BECO Boiler Baffle Walls

to make the old boiler *better* than when it was new and better than such new boilers of today as are not equipped with BECO Baffles.

The BECO is a great money saver and a great money maker. The BECO positively eliminates all leakage and short circuiting of valuable hot gases. It eliminates leakage PERMANENTLY. The trouble with solid and reinforced baffles is—they *crack* because of their very rigidity. The BECO is *not* rigid; it is *flexible*. The positive expansion joints in the BECO are responsible for the performance of this remarkable baffle wall.

With the BECO you get maximum efficiency . . . no slagging . . . correct gas velocity . . . minimum chimney gas temperature . . . and permanence of construction.

A sketch of your boiler with present performance facts will enable us to tell you what the BECO will do for you. No obligation whatever. We can probably save you thousands of dollars.



The above photograph shows the construction of BECO Baffle Walls. A BECO Corrugated Sheet Metal Separator, shown at the right, is placed in every diagonal alley, assuring positive expansion joints. Leakage is impossible. Cracking and breaking are impossible.

BOILER ENGINEERING CO.

24 Commerce St., Newark, N. J.

Canada: F. W. Pennock & Co., 1430 Bleury St., Montreal
Great Britain: Detrick Arch Co., Ltd., London, W. C. 1

Masons

who know good fire brick construction insist on

HYTEMPITE

(Reg. U. S. Pat. Off.)

For Furnace Construction and Maintenance

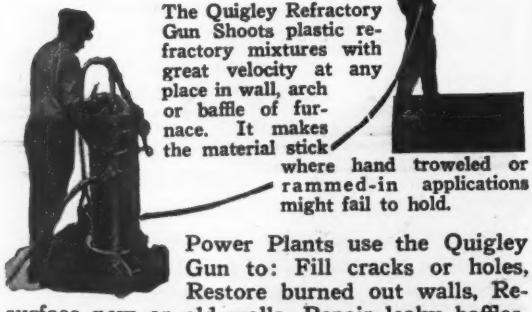
Because Hytempite gives more than a surface bond. It bonds through the entire wall. The thin strong joint resists erosion. Fire Brick bonded with Hytempite give long service.

Quantity guaranteed is 400 lbs. to lay 1000 firebrick.

HYTEMPITE is universally used for laying up firebrick in all types of furnaces, boiler settings, arches, etc. (and when mixed with crushed old firebrick or Ganisand), for monolithic construction, baffles, patches, repairs, special shapes and tile, etc.

The Quigley Gun

Speeds Furnace Repairs and Construction



The Quigley Refractory Gun Shoots plastic refractory mixtures with great velocity at any place in wall, arch or baffle of furnace. It makes the material stick where hand troweled or rammed-in applications might fail to hold.

Power Plants use the Quigley Gun to: Fill cracks or holes, Restore burned out walls, Resurface new or old walls, Repair leaky baffles, Build new baffles, etc. Booklet RG130.

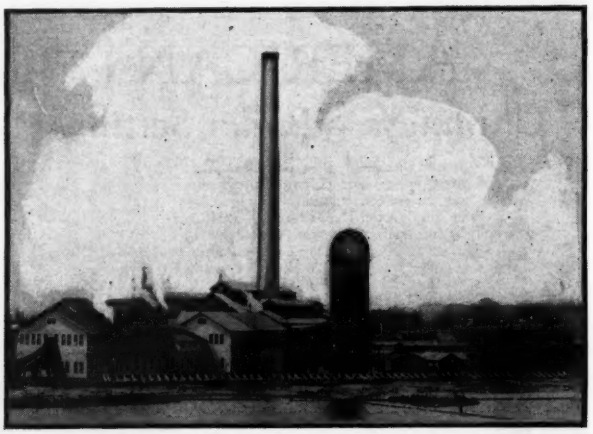
A copy of "Hytempite in the Power Plant" should be in the hands of every Power Plant Superintendent and Engineer. Ask for yours.

QUIGLEY FURNACE SPECIALTIES COMPANY INC.

56 West 45th Street New York

REFRACTORY MATERIALS FOR FURNACE CONSTRUCTION AND MAINTENANCE
ACID PROOF CEMENTS ACID AND ALKALI PROOF COATINGS

Stock and Service through Agents in Every Industrial Center



SERVING ALL INDUSTRIES

as in this Lumber plant

THE CEMENT-GUN

TRADE MARK

can also save money in your plant!

A FEW USERS

Penick & Ford
Lincoln Oil Refining Co.
Union Saw Mill Co.
Simmons Company
Fisher Body Corp.
Hammermill Paper Co.
Erie Forge & Steel Co.
Sheel Petroleum Co.
Allis-Chalmers Mfg. Co.
Sugar Pine Lumber Co.
Williams Cypress Co.
Nekoosa-Edwards Paper Co.
Armour & Company
A. M. Byers Co.
Allegheny Steel Co.
American Steel Foundries
Springfield Gas Lt. Co.
American Rolling Mill Co.
Natl. Cash Register Co.
Jones & Laughlin Steel Co.
Rockford Electric Co.
Indiana Electric Corp.
Ohio Public Service Corp.
Carnegie Steel Co.
Iowa Public Service Co.

GIVE the "Cement-Gun" a chance to prove the savings it will effect in your plant similar to those it is effecting in plants of hundreds of concerns!

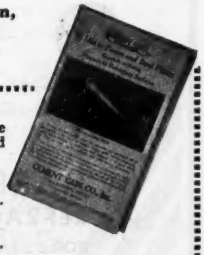
Inside and outside of industrial plants and central stations the country over, the "Cement-Gun" proves the economies it brings as has been the case in the **CROSSETT LUMBER COMPANY'S** plant, at Crossett, Arkansas, pictured above.

Use Coupon for valuable information.

The Only Machine that Handles Dry Materials!

CEMENT GUN COMPANY, Inc.

Allentown, Penna.



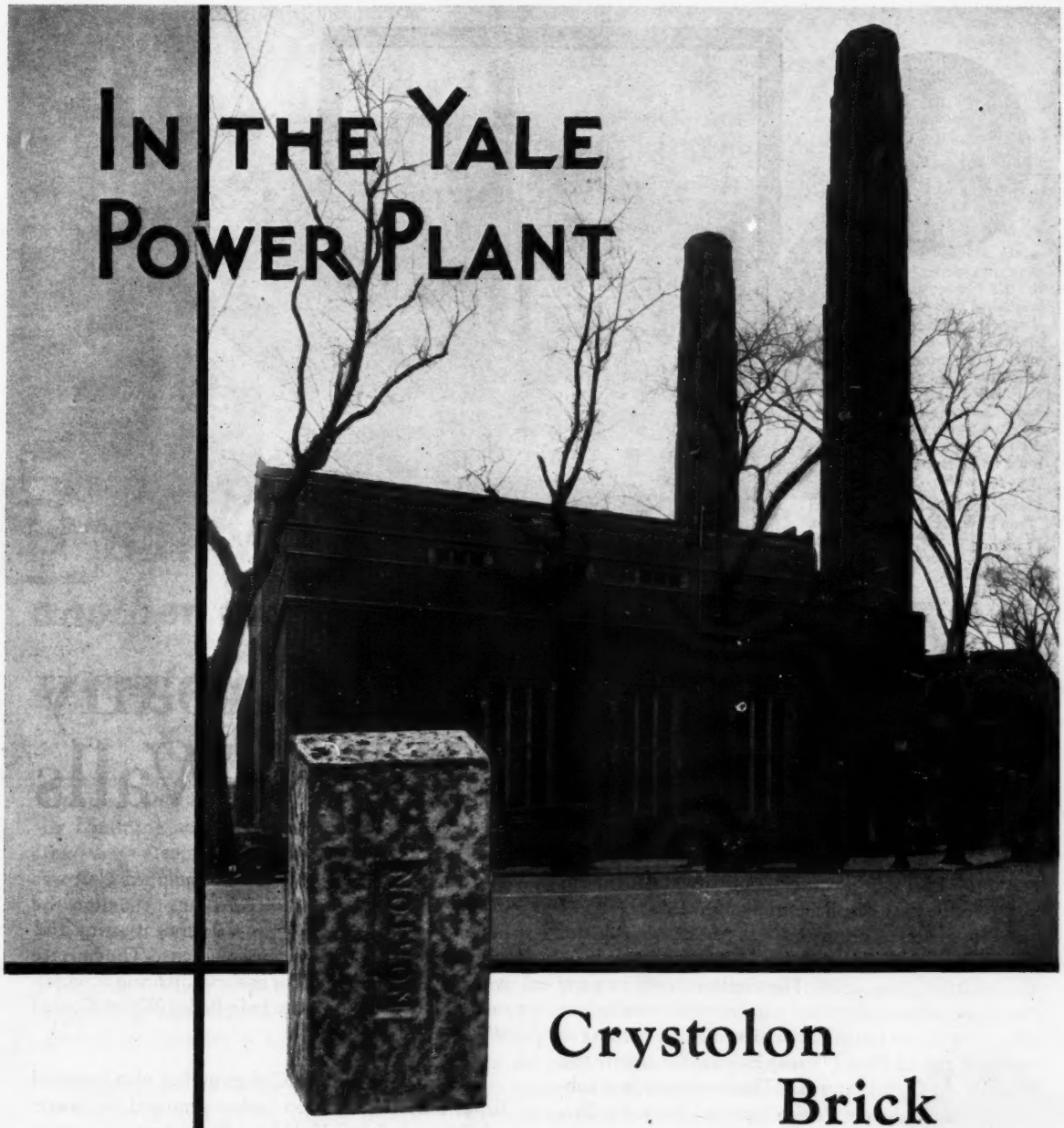
Cement-Gun Co., Inc., Allentown, Penna.
Please send us full information regarding the many uses of the "Cement-Gun" inside and outside the plant.

Name .....

Address .....

City .....State .....

IN THE YALE POWER PLANT

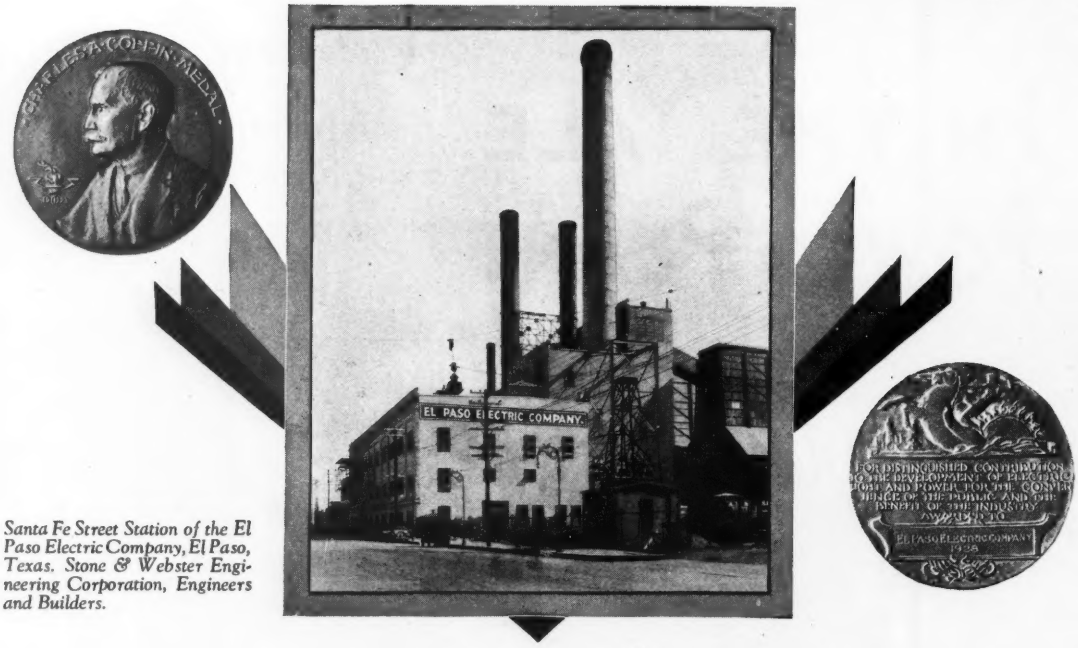


Crystolon Brick

To insure long periods on the line for the three new boilers in this modern university power plant Crystolon Brick were used along the side walls at the clinker line and in the back walls. Crystolon Brick are a silicon carbide product made especially to meet the severe conditions in modern high temperature, high pressure installations.

NORTON REFRACTORIES

NORTON COMPANY
Worcester, Mass.
New York Chicago
Cleveland



Santa Fe Street Station of the El Paso Electric Company, El Paso, Texas. Stone & Webster Engineering Corporation, Engineers and Builders.

El Paso Electric Company Repeats With Bailey Walls

THE El Paso Electric Company through the application of efficient management and sound engineering principles was presented with the Charles A. Coffin Award for 1928 at the N.E.L.A. Convention, June, 1929. The citation reads in part, "increase service reliability, exceptional overall plant efficiency . . . are the major achievements which have won for the El Paso (Texas) Electric Company the Charles A. Coffin Award." This company is a subsidiary of Engineers Public Service Company, Inc.

Aiding in establishing this record were Bailey Water-Cooled Walls on the side walls and front and rear arches of the furnace of the main steam-generating unit—a chain-grate stoker-fired boiler of 10,660 sq. ft. of heating surface. These walls were put in service in October, 1927. During the period covered by the award the Bailey-Furnace-Equipped Unit was in operation practically 100 per cent of the time, the boiler operating at as high as 300 per cent rating and with little furnace maintenance expense. The furnace was recently converted for gas and oil firing at which time it was rebuilt to include Bailey Water-Cooled Walls on all four sides.

The El Paso Electric Company has also installed Bailey Furnaces on two boilers arranged for gas or oil firing, each of 15,253 sq. ft. of heating surface in a new station now under construction.

This continuous use of Bailey Water-Cooled Walls by the El Paso Electric Company is evidence of the highly satisfactory performance and economy of the Bailey Protected-Tube Type of Water Wall.

FULLER LEHIGH COMPANY, FULLERTON, PENNA.—*A Babcock & Wilcox Organization* 1-132

FULLER (FL) LEHIGH

PULVERIZED-COAL EQUIPMENT —WATER-COOLED FURNACE WALLS

Deepwater Station

Located on the Delaware River near Pennsgrove, N. J. This station is owned jointly by the American Gas and Electric Company and The United Gas Improvement Company. It was designed and constructed by Stevens and Wood, Incorporated, 60 John Street, New York. This plant also serves the great industrial plant of E. I. Dupont de Nemours & Co. See leading article in the last previous issue of "Power Plant Engineering" for complete description of this 1200 lb. station.

DEEPWATER STATION

another modern central station served by CONNERY CONSTRUCTION

Utilizing the most modern methods by obtaining economical heat balance, this new Deepwater Station presents throughout many new features in Central Station construction. In keeping with the best of equipment used throughout this station are the Duct Work and Flues and the three self-supporting steel stacks furnished and erected by Connery & Company, Inc.

Superior service to the vast majority of industrial and public utility plants has made Connery Construction the dependable and economical construction for breechings, uptakes, air ducts and smoke flues.

Connery's is built for long life with no leakage and with absolute safety from bulging. The accordion-like construction gives ample expansion and contraction, greater strength and rigidity for weight. Electrically welded joints prevent internal corrosion.

Connery's Improved Construction "costs no more than ordinary types;" yet its record proves many advantages.

Consult us freely. Write for information on why Connery's is installed in the leading stations.

Gold Medal awarded to Connery & Company at the Philadelphia Sesqui-Centennial "For Improved Expansion, Compensating and Stiffened Draft Flues and Dampers."

Electrically Welded Air Duct

WE RECOMMEND

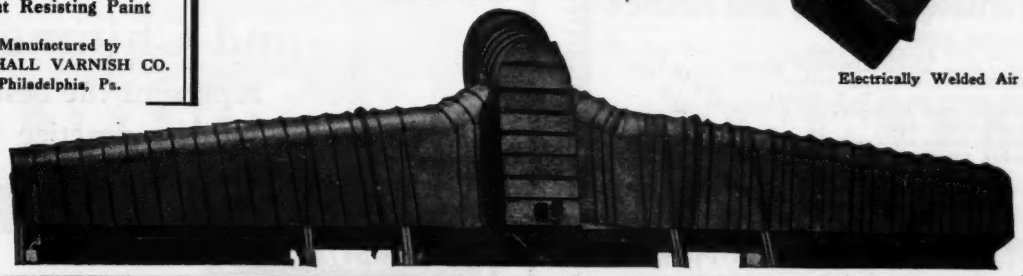
TRUFILM

Heat Resisting Paint

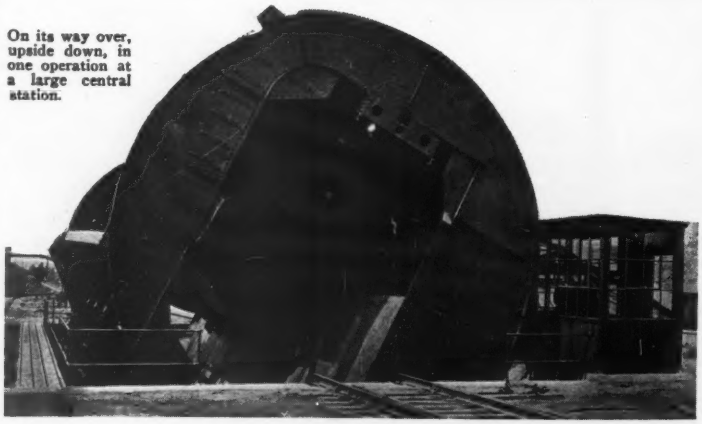
Manufactured by
PASCHALL VARNISH CO.
Philadelphia, Pa.

CONNERY & COMPANY, Inc.

4000 North Second St., Philadelphia, Pa.
Branch Office: New York



On its way over, upside down, in one operation at a large central station.



After the Freight is Paid—Then—

Often the cost of handling coal after a Central Station receives it approaches the freight charges.

Where coal is handled in quantity, the "Wellman" Revolving Car Dumper is the first step toward economy.

It dumps coal at a surprisingly low cost. It permits the use of the most modern conveying and handling machinery.

It short circuits a lot of expense.

Write us for further information.

THE WELLMAN-SEAVER-MORGAN CO.
ENGINEERS CONSTRUCTORS MANUFACTURERS
Cleveland, Ohio

New York at 30 Church St.
Birmingham at 1101 American Trust Bldg.
Chicago at Room 523—549 West Washington Blvd.
In Canada—"Canadian Wellman-Seaver-Morgan Co., Limited," 307 Reford Bldg., Toronto—821 Castle Bldg., Montreal
Mexico City at Edificio Oliver, 16 De Septiembre No. 5

There are now more than 12,000 installations of DETRICK ARCHES and DETRICK SECTIONAL SUPPORTED WALLS in satisfactory service.

The experience gained in solving this large number of furnace problems is offered to you for the solution of your own.

M. H. DETRICK COMPANY
140 S. Dearborn St., Chicago
-o-
New York: 50 Church St.
Pittsburgh: Empire Bldg.
Detroit: Murphy Bldg.
San Francisco: Russ Bldg.
Sales Engineers in principal cities

DETRICK ARCHES & WALLS

R&E

Refractory Cements insure longer life and greater economy *at less cost per lb.*

Refractory & Engineering Corporation
50 Church St., New York
Pittsburgh Baltimore Philadelphia Chicago

"STEEL MIXTURE"
Furnace Linings and Arches

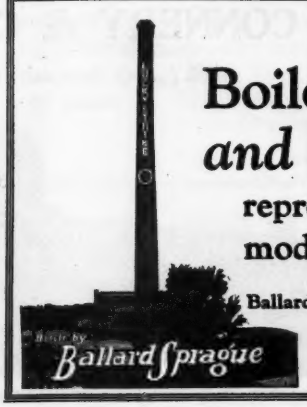
Complete Boiler Settings
Veneer and Air-Cooled Linings
Boiler Door Arches—Fire-Box Blocks
Flat Suspended Furnace Arches
Back Arches for H. R. T. Boilers
Blow-Off Pipe Protectors
Standard Fire Brick
High-Temperature Cement
Carbex (Silicon Carbide) Super Refractories

Write for Booklet No. 29

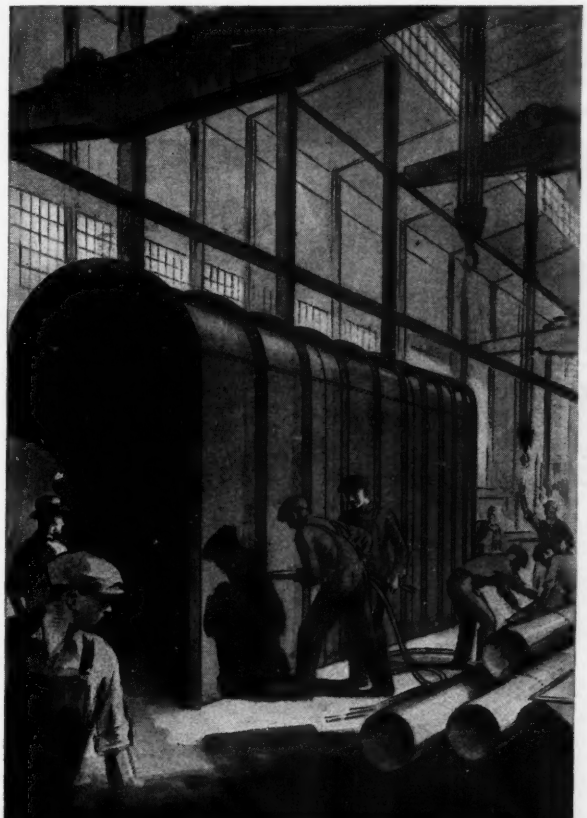
McLEOD & HENRY CO.
29 Monroe Street, Troy, N. Y.
Branch Offices: New York, Boston, Cleveland, Detroit

REG. U.S. PAT. OFF.

Our Boiler Settings *and* Chimneys represent the best modern practice



Ballard, Sprague & Company, Inc
25 East 26th Street
New York



BREECHINGS AIR-DUCTS STACKS

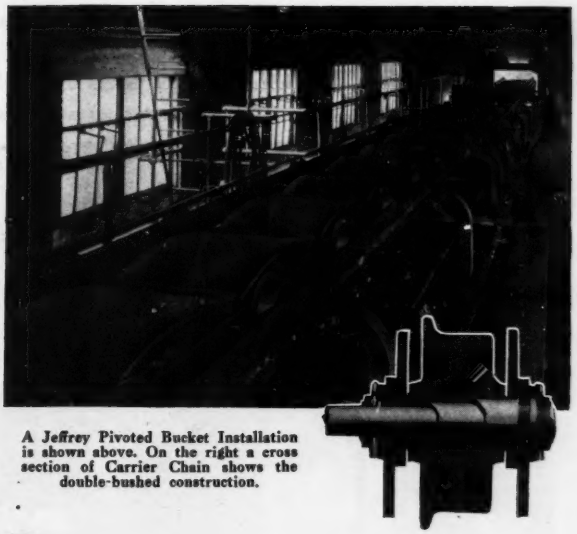
Plate & Sheet Steel Fabrication of all kinds for Industrial Plants & Super Power Stations

Remember to get our quotation

Littleford Brothers
Cincinnati, Ohio

Littleford

BREECHINGS - FORCED AND INDUCED DRAFT DUCTS
TANKS - SPECIAL PLATE STEEL WORK



A Jeffrey Pivoted Bucket Installation is shown above. On the right a cross section of Carrier Chain shows the double-bushed construction.

5 Important Features
of Jeffrey Pivoted Bucket Carriers

1 The double bushed construction of the Jeffrey Pivoted Bucket Carrier Chain takes all the wear from the through rod. Replacement of the bushings provides practically a new chain. The chain sidebars are made of high carbon rolled steel.

2 The full mouth of each bucket is open to receive and discharge the maximum size lump. There are no rods through the buckets.

3 Buckets are securely suspended midway between the articulation points of chain, and the trunnion passes through both sidebars.

4 One point suspension of buckets in glass hard bearings makes positive and easy dumping regardless of chain alignment.

5 Buckets are easily removed without disturbing chain.

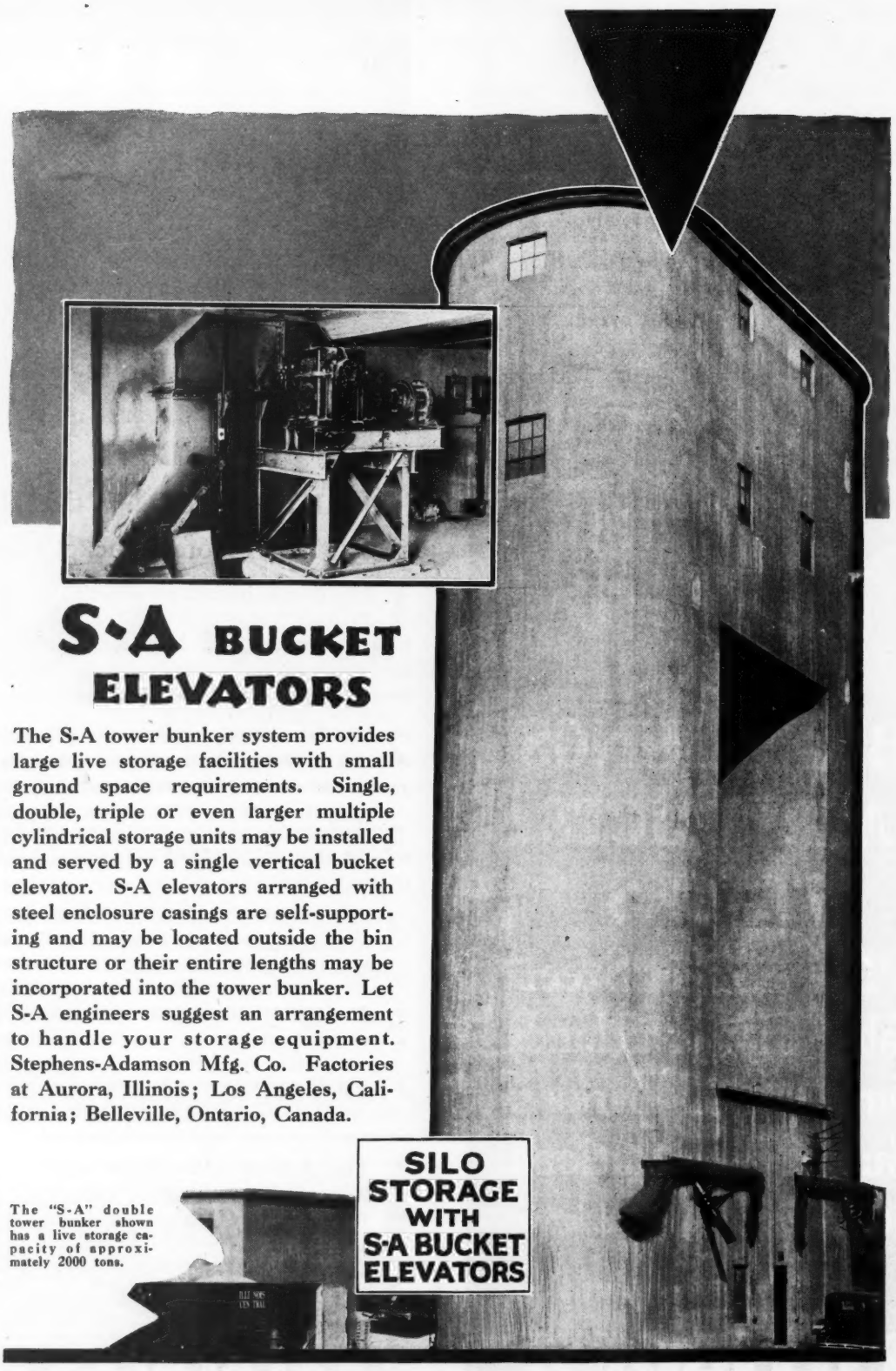
If you are interested in handling coal and ashes we will be glad to send you a copy of our Catalog No. 210-G.

The Jeffrey Manufacturing Company
905-99 North Fourth St., Columbus, Ohio

New York	Utica	Detroit	Denver
Buffalo	Boston	Chicago	Houston
Rochester, N. Y.	Scranton, Pa.	Charleston, W. Va.	Salt Lake City
Philadelphia	Cincinnati	Milwaukee	Birmingham
Pittsburgh	Cleveland	St. Louis	Atlanta

Jeffrey Manufacturing Co., Ltd. of Canada, Head Office: Montreal—Branch Office: Toronto

JEFFREY
MATERIAL HANDLING EQUIPMENT



S-A BUCKET ELEVATORS

The S-A tower bunker system provides large live storage facilities with small ground space requirements. Single, double, triple or even larger multiple cylindrical storage units may be installed and served by a single vertical bucket elevator. S-A elevators arranged with steel enclosure casings are self-supporting and may be located outside the bin structure or their entire lengths may be incorporated into the tower bunker. Let S-A engineers suggest an arrangement to handle your storage equipment. Stephens-Adamson Mfg. Co. Factories at Aurora, Illinois; Los Angeles, California; Belleville, Ontario, Canada.

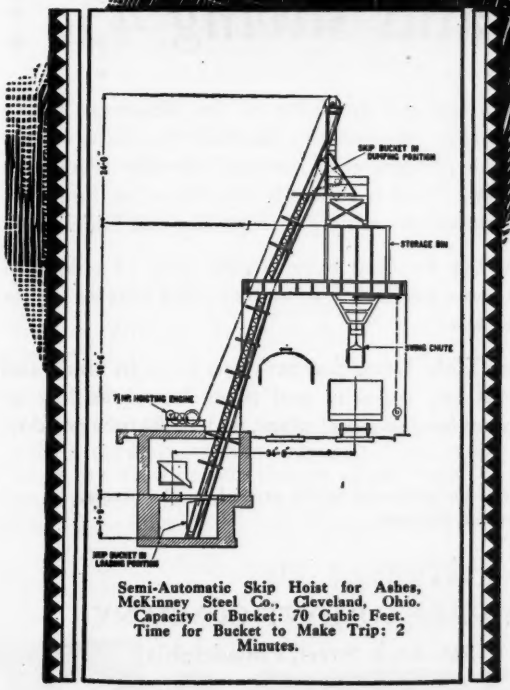
The "S-A" double tower bunker shown has a live storage capacity of approximately 2000 tons.

SILO STORAGE WITH S-A BUCKET ELEVATORS

STEPHENS ADAMSON

S-A BELT CONVEYORS

COAL··ASH··ORE HANDLING EQUIPMENT



Semi-Automatic Skip Hoist for Ashes, McKinney Steel Co., Cleveland, Ohio. Capacity of Bucket: 70 Cubic Feet. Time for Bucket to Make Trip: 2 Minutes.

Profitable hands control ...they do not Handle

Human strength is unprofitably spent when men handle bulk materials.

Human hands earn their way when they control conveying machinery or when they guide material to and from these installations.

Whatever the installation—belt conveyor, skip hoist, bucket elevator—individually or in combination—Bartlett-Snow equipment operates steadily and profitably—because each job is designed with a well rounded knowledge of the work it is to do.

An engineering organization stands ready to study *your* problem, and to work closely with you in its solution.

THE C. O. BARTLETT & SNOW CO.
6238 Harvard Ave. Cleveland, Ohio
Representatives for the Dominion of Canada
PEACOCK BROTHERS, LIMITED, MONTREAL

Bartlett - Snow

Storing coal for 2½ cents a ton . . .

. . . and *saving* 43c!

THE simplicity and flexibility of the Beaumont Cable Drag Scraper permits the Morrell St. Plant of the City of Detroit to store coal received directly from self-unloading boats. Coal is stored in any direction (and just as easily reclaimed) by simply shifting the Tail Block Car.

This plant has handled over 300,000 tons of coal at a saving of 43 cents per ton, with an operating cost as low as 2½ cents per ton!

Beaumont Cable Drag Scrapers are built in sizes and types to meet any capacity and plant layout as low as 10 tons an hour for the small plant, up to 6000 tons per day.

Write for additional details or send for the nearest Beaumont Engineer.

R. H. BEAUMONT COMPANY
346 Arch Street, Philadelphia

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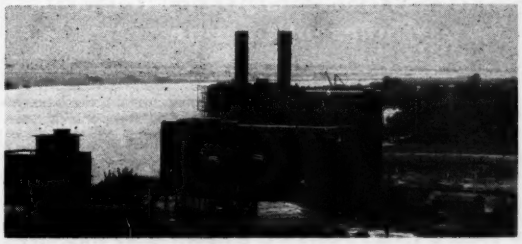
BEAUMONT CABLE DRAG SCRAPERS

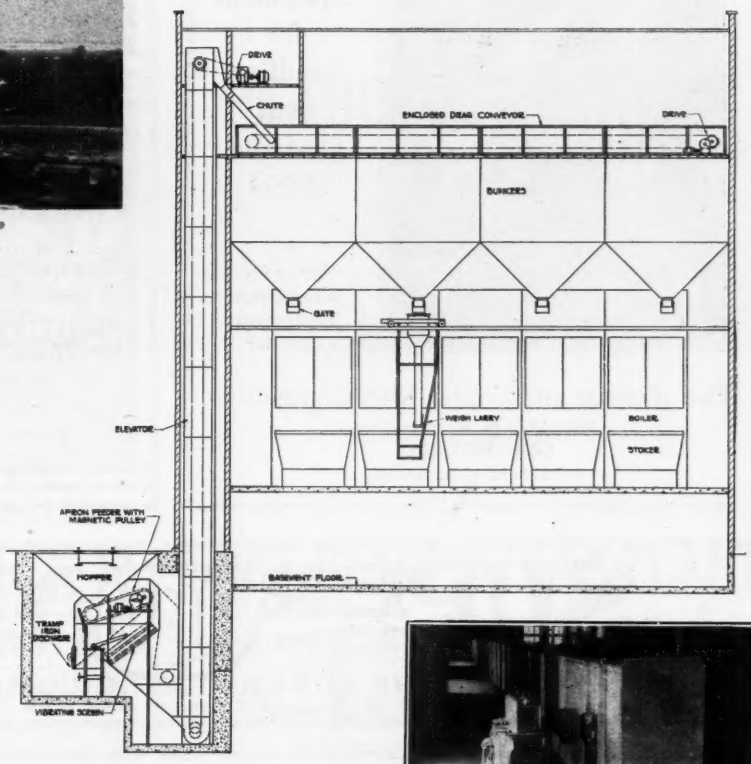
The Ohio River Station Coal Handling System of the Southern Indiana Gas and Electric Co.

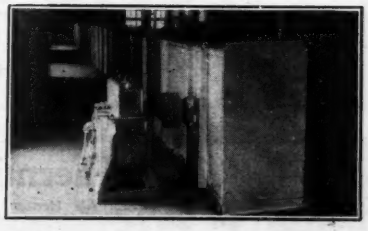
[A FAIRFIELD INSTALLATION]



The 20,000 K. W. Ohio River Station of the Indiana Gas and Electric Company at Evansville, Indiana, is a fine example of modern power plant construction. The Fairfield Coal Conveying and Handling equipment used to supply two 11,520-sq. ft. cross drum boilers is entirely enclosed to eliminate dust. The Fairfield equipment has a carrying capacity sufficient for one additional boiler unit.

Fairfield Conveying Equipment provides rapid, economical coal and material transmission for every industrial purpose. Our engineers will be glad to cooperate with you in solving your conveying problems in the most economic and efficient manner. Write for complete information.



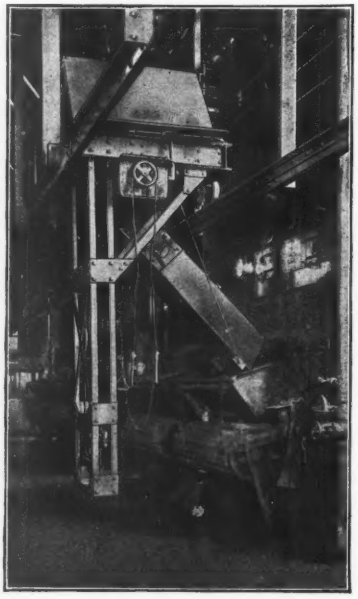


Fairfield Engineering Co., coal handling system with a capacity of 60 t. per hr. Consisting of: 1—18 by 18-ft. track hopper made from ¼-in. steel plate; 1 apron feeder, 30 in. wide by 7 ft. long; 1—3-ft. wide by 6-ft. long vibrating screen with 3 by 3-in. openings; 1 bucket elevator, 96-ft. between centers consisting of 20 by 8 by 8½ in. buckets traveling at 190 ft. per min.; 1 drag conveyor 87 ft. between centers with 16 by 8-in. flights.

THE FAIRFIELD ENGINEERING CO.
MARION, OHIO

FAIRFIELD
ELEVATING and CONVEYING MACHINERY

Economize



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For all boilers—150 H. P. up, using any bituminous coal, lignite, petroleum coke, pitch or charcoal.

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COAL BREAKERS AND CLEANERS (Bradford Type)
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"Pennsylvania" *STEELBUILT* Coal Preparation Machinery offers engineers and operators a wide selection of types and sizes, specialized for heavy, continuous service in Central Stations, Gas Works and Industrial Power Plants.

POSITIVE TRAMP IRON PROTECTION
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Thermix Air Heater and Thermix Stack

THERMIX

Thermix Air Heater
Plate type; for recovery of heat from flue gas to heat air for preheating or industrial purposes. Write for Catalog 12-T.

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An induced draft fan and stack built as a unit, thereby saving power, space and cost. Write for Catalog 12-S.

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An apparatus for effective cinder and dust removal combined with a Thermix Stack, or furnished for existing stack installations as a cinder removing fan. Write for Catalog 12-C.

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COMPLETE POWER PLANTS
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Locomotive Cranes, Gantry Cranes, Flexible-Tread Cranes, Shovels, Draglines and Ditchers, Truck Cranes, Road-Wheel Cranes, Clamshell & Orange-Peel Buckets

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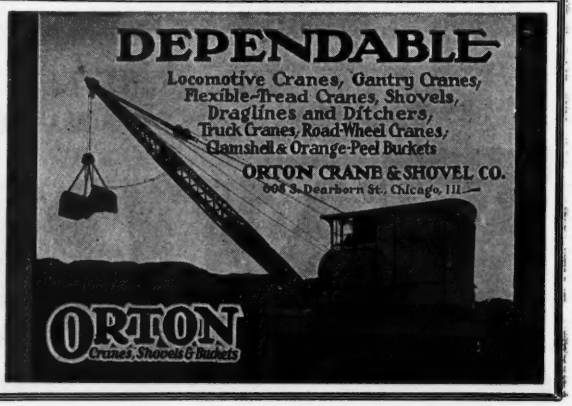

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for
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BETHLEHEM STEEL CO., *General Offices*, BETHLEHEM, PA.
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DETROIT UNDERFEED STOKERS

Ask For Bulletin 879

Detroit Stoker Company
879 General Motors Bldg - Detroit.

Huber Type "MS" Stoker

HUBER STOKERS

A Stoker for Every Boiler

Write for interesting records of performance in representative plants, and a copy of "Five Minutes With the Coal Bill."

FLYNN AND EMRICH COMPANY
307 N. Holliday St., Baltimore, Md.

NEEMES GRATES

Neemes Improved Shaking and Dumping Grates have for 55 years been the choice of careful and discriminating buyers because any kind of coal can be burned on them with the best possible combustion.

NEEMES FOUNDRY, INC.
186 First Street Troy, N. Y.
Manufacturers of Round and Square Grates and Fully Automatic Stokers
Established 1874

ECONOMY QUALITY 1874 NEEMES SERVICE

175,000
BOILER HORSEPOWER

DEVELOPED BY

285
PEABODY BURNERS

FOR

GAS AND OIL

AT THE

LONG BEACH STEAM PLANT
Southern California Edison Company
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ENGINEERS AND CONSTRUCTORS

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An accomplishment achieved through years of development

McClave, type SR. Underfeed Stoker

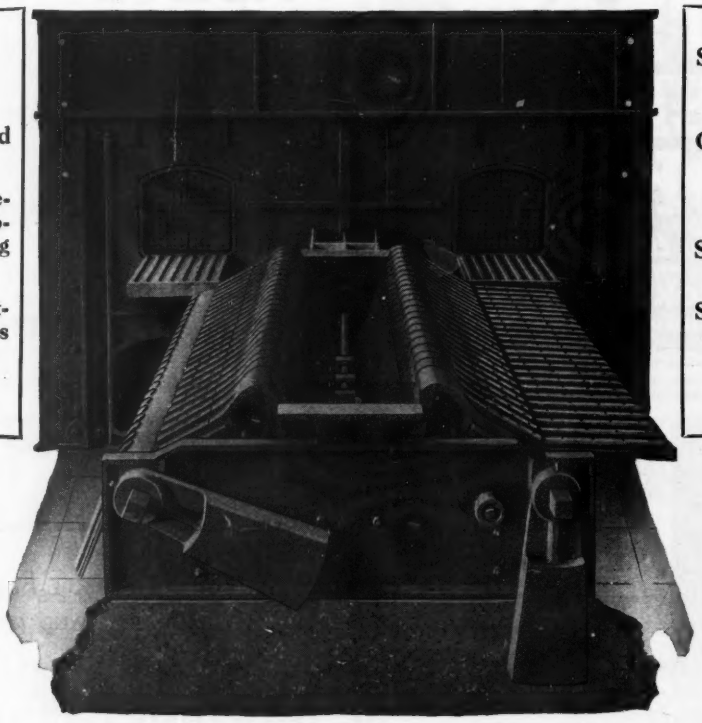
Not merely a desire to add another stoker to the McClave line, but an aim to fashion a stoker that would give maximum economic results is the reason for our spending years of effort in the development of the type "SR" Underfeed Stoker.

Special drive.

Completely enclosed driving unit.

Special friction safety clutch—no obsolete shearing pin.

Adjustable connecting rod—regulates coal feed.



Sectional retort tuyeres with a staggered mesh design.

Counterbalanced dump plates permit easy operation.

Sectional rabbeted grate bars.

Special dampers controlling air to every part of the stoker.

McCLAVE-BROOKS COMPANY

Sole Makers of the McClave Grates Since 1883

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McClave STOKERS AND GRATES

McCLAVE STOKERS & GRATES

There are not very many ways that a company can invest money and show a return on it of 59% annually. Yet here is a story of how the Manhattan Rubber Co. accomplished this by installing Harrington Stokers.

How many Investments Pay 59%?

by JAMES W. ARMOUR*

In spite of the prosperity of this country at the present time, how many investments are netting 59% annually? Yet the money which the Manhattan Rubber Company invested in Harrington stokers in order to be able to burn No. 3 buckwheat anthracite coal shows just such a tremendous return. This company several years ago was burning oil. An investigation indicated that they could produce steam at a considerably lower figure by burning No. 3 buckwheat anthracite.

They installed four Harrington stokers under their 4–665 H.P. boilers in the summer of 1926. Through the installation of these stokers they were able to reduce the cost of a thousand pounds of steam from $.419 to $.253, which resulted in an annual saving of $54,866.27 or a net annual return on the investment of 59%. The Harrington when burning the No. 3 buckwheat anthracite operated over six month periods, which includes banking losses, etc., at an efficiency of 74.5%; remarkable performance.

The Harrington Stoker Efficiently Burns

Coke Breeze
Anthracite
Lignite
Bituminous Coals

Suppose you were able to make a similar saving in your plant through the installation of Harrington stokers. It seems fair to assume that an engineer would be sitting quite pretty with the big boss, if he could recommend the installation of equipment which would net his company a dividend of 59% annually on the money invested. And the beauty about recommending Harrington stokers is the fact that results throughout the country with this stoker are so satisfactory that there is scarcely a possibility of "fumbling the ball."

Harrington stokers not only burn the different sizes of anthracite and silt but they also burn efficiently coke breeze, lignites and bituminous coals. It is certainly an extremely flexible stoker. At the Fitchburg Gas and Electric Co., their regular diet is coke breeze, then a little anthracite yard sweepings and then eastern bituminous coal. At the University of Pennsylvania, during a coal shortage they shifted from No. 3 buckwheat to a very poor grade of river coal and then to a low grade bituminous coal. The ability of the Harrington to burn these different coals has gotten many of its users out of a rather serious predicament.

The Harrington stoker has many features which makes it excel from a maintenance standpoint. Maintenance is not only low but when replacements have to be made they can be made easily. There are no shafts, bearings, revolving sprockets or eccentrics at the rear of the stoker, every moving part comes to the front of the stoker every revolution of the chain. Grate clips can be replaced while the stoker is in operation. This accessibility, making replacement of parts easy, together with low maintenance is the feature which makes the Harrington stoker so popular even after age creeps in.

The Riley Stoker Corporation will gladly send you a catalog describing this outstanding travelling grate stoker. Write for catalog No. H-103.

*Vice-President and Engineering Manager, Riley Stoker Corporation

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WORCESTER, MASS., U. S. A.
BOSTON NEW YORK PHILADELPHIA PITTSBURGH BUFFALO CLEVELAND DETROIT TACOMA ST LOUIS
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Review Year's operation and find fuel bills cut 10 to 15% *with* KELLY IMPROVED HAND STOKERS

Kelly Improved Hand Stokers effect big savings in fuel and labor, consistently, and with a small investment. These stokers, in designs, styles and sizes that meet the latest combustion requirements, burn any grade of coal, even the cheapest, burn it smokelessly and keep hot fires.

Manipulated entirely by outside levers, requires no opening of doors except for feeding coal. Due to their construction of special heat-resisting iron, Kelly Stokers are also distinguished for their durability, long life, and freedom from repair expense.

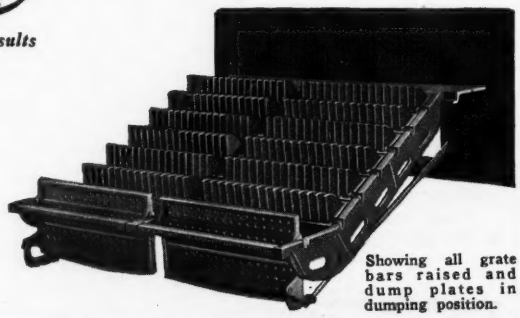
Why not install Kelly Improved Hand Stokers right under your present boilers and be prepared to show a saving in fuel and labor costs for 1930! Write for information.

Specify Kelly

Improved Hand Stokers
Rocking and Dumping Grates—Style A and Style B
Portable Kiln Grates
Circle Grates
Grate Bars—all patterns
Boiler Fronts

When you buy KELLY STOKERS-GRATES GOSHEN IND. *you buy results*

Easy to operate
Easy to install



Showing all grate bars raised and dump plates in dumping position.

The Kelly Foundry & Machine Co.
617 Ninth Street, Goshen, Ind.
POWER PLANT ENGINEERS
Established 1887
NEW YORK OFFICE: 53 Park Place — CHICAGO OFFICE: 178 W. Adams St. — PHILADELPHIA OFFICE: Bourse Bldg.

Gets more heat from coal than any other combustion system
Capacities up to 1,000,000 pounds of steam per hour

AIR COAL Taylor Unit for lower power costs

The TAYLOR UNIT and A-E-CO FURNACE ARMOR

A-E-CO

American Engineering Company, Philadelphia
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POWER *and* HEATING BOILERS *for all* INDUSTRIAL PURPOSES

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TITUSVILLE PENNSYLVANIA

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BOILERS—WATER WALLS
SECTIONAL—ALL STEEL
ALL SIZES—ALL PRESSURES

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THE BABCOCK & WILCOX COMPANY

ESTABLISHED 1868

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Manufacturers of

Water-Tube Boilers, Steam Superheaters, Air Preheaters, Economizers,
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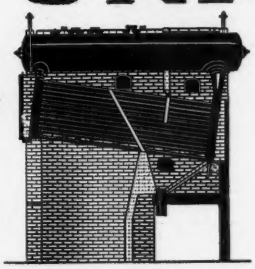
UNION WATER TUBE BOILERS



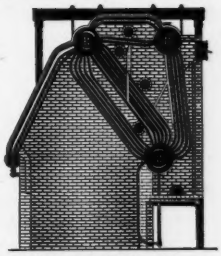
Also made in cross drum type. (Patented.)

UNION BOILERS are built in longitudinal drum, cross drum and vertical bent tube types for practically all operating pressures and sizes.

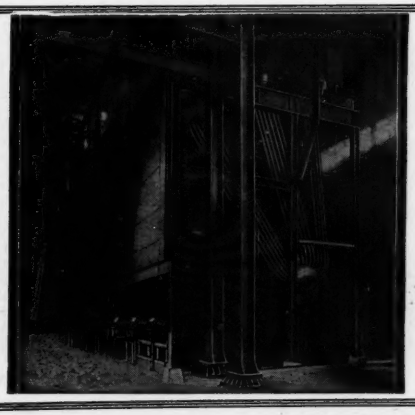
Designed and built by an organization backed by forty years experience in the manufacture of high pressure steam boilers exclusively, in a modern and specially equipped plant.

Sales offices in principal cities are at your service.

ERIE UNION IRON WORKS PENNA.



Made in 3 and 4 drum types. (Patented.)



Space Costs Money!

Connelly Boilers are so designed that they can be built into units of larger capacity than any other boiler occupying the same amount of space—just another reason why they are more economical in the long run. Our catalog explains in detail the patented design. A copy will be sent you promptly.

Built in units from 200 to 4300 H. P. and for steam pressures up to 450 lbs.

The CONNELLY BOILER COMPANY, CLEVELAND, O.

Boiler Specialists for 54 Years

Pulverized Coal Apparatus
Water Cooled Furnaces
High Pressure Boilers

OF

ALL SIZES

ERIE CITY IRON WORKS

ERIE, PENNA. U.S.A.

Remarkable Efficiencies

Shown by

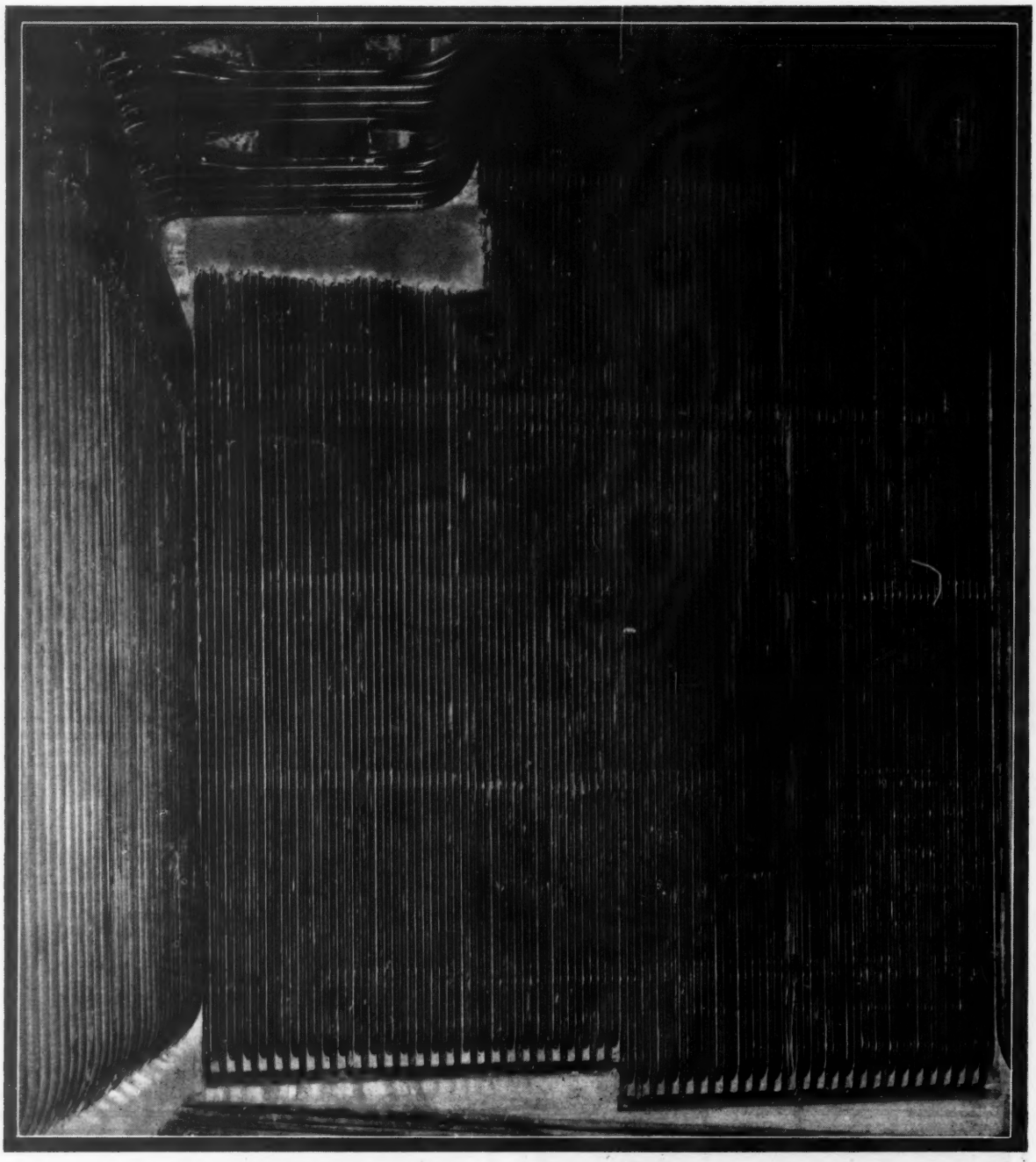
BADENHAUSEN (Patented)
Boilers
Preheaters
Superheaters
Water Cooled Furnace Walls

Each a unit in itself, yet an integral part of the boiler proper
Surveys and Tests by outside Engineers forwarded on request

BADENHAUSEN CORPORATION

General Office and Works

Cornwells Heights, Bucks County, Pa.



1400 lb. Furnace

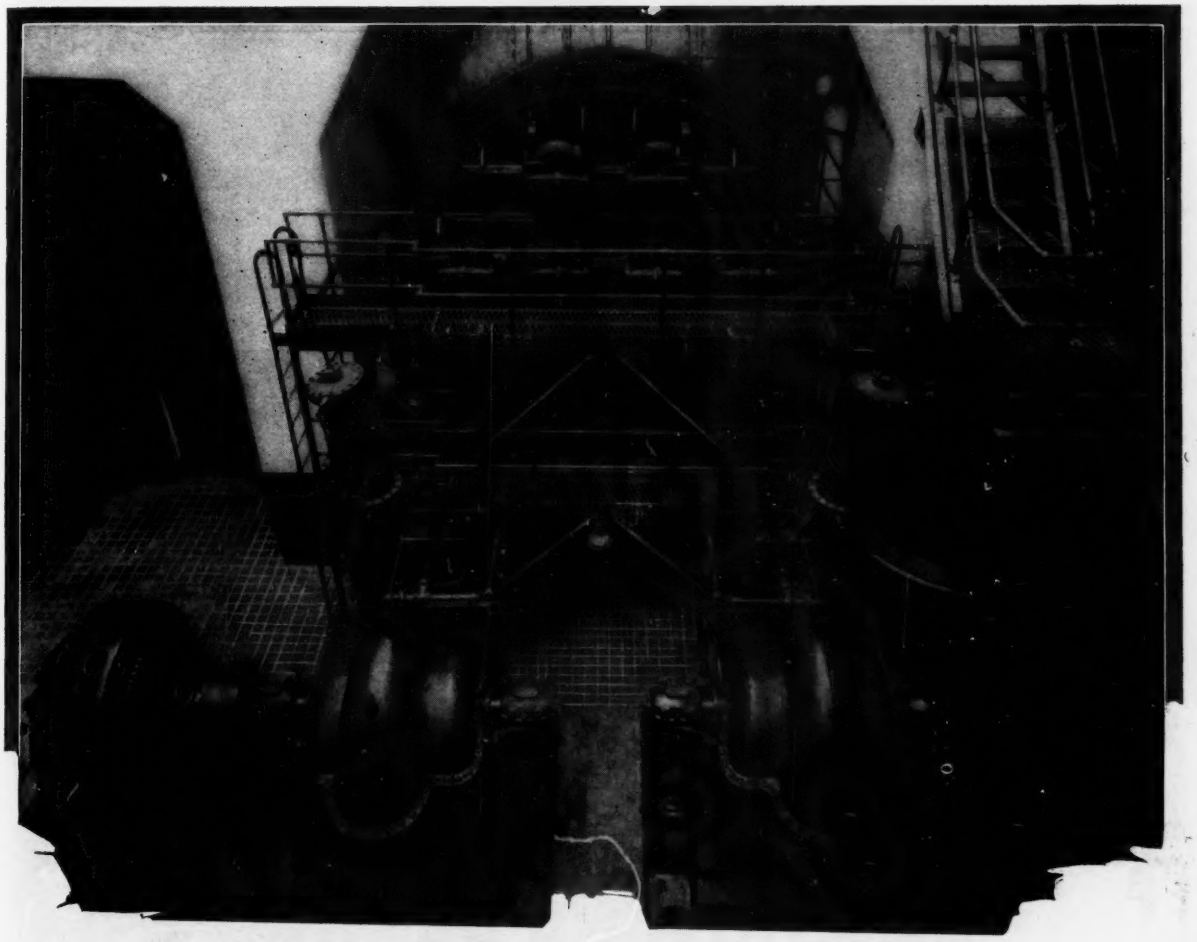
Photograph taken in the furnace of a 2850 hp. boiler. The boiler is designed for operation at a pressure of 1400 lb. per sq. in. gage.

This view shows one side wall of the furnace. It consists of a Foster radiant heat superheater panel 22 ft. wide x 29 ft. high. It superheats half of the steam generated to a final temperature of 750 deg. F.

At the left is the front water wall, at the bottom a slag screen and at the upper left the pulverized fuel burners.

AERO UNIT COAL PULVERIZERS
AIR HEATERS CENTRIFUGAL PUMPS
CONDENSERS COOLING TOWERS
ECONOMIZERS EVAPORATORS
EXPANSION JOINTS FEED WATER HEATERS

FOSTER



Foster Wheeler Equipment
For High Pressure Steam Stations

1400 pound gage pressure is carried in the new station here illustrated. The Foster Wheeler Corporation furnished:

Radiant heat steam superheaters, convection steam reheaters, 55,000 sq. ft. condensers, steam jet air pumps, circulating pumps, condensate pumps and feed water heaters.

FOSTER WHEELER CORPORATION

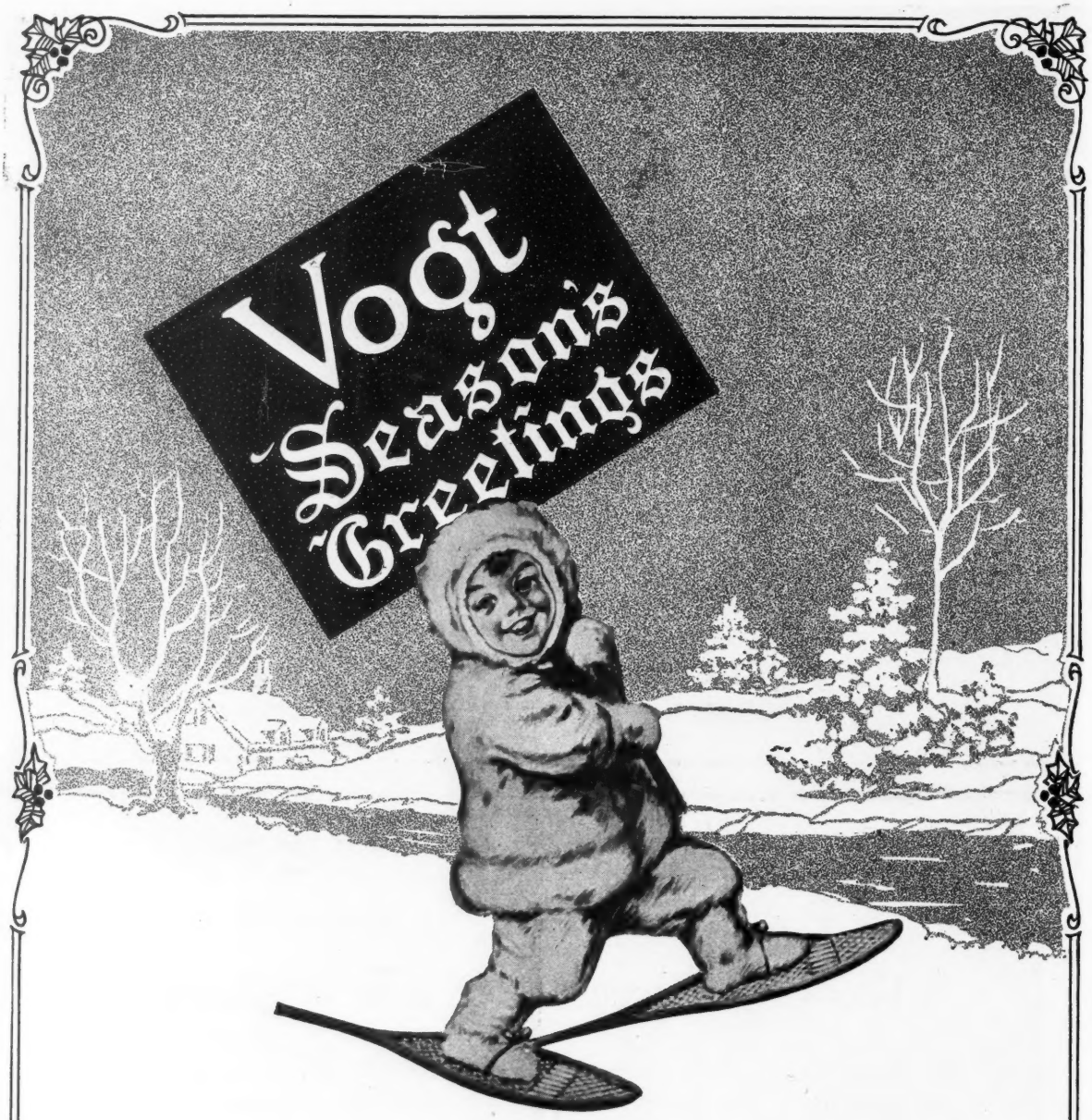
165 Broadway, New York, N. Y.

Branches in Principal Cities

Foreign Associates—
Foster Wheeler Limited; London, England.
Societe Anonyme Foster Wheeler; Paris, France.
Foster Wheeler Limited; Toronto-Montreal-Vancouver, Canada.

WHEELER

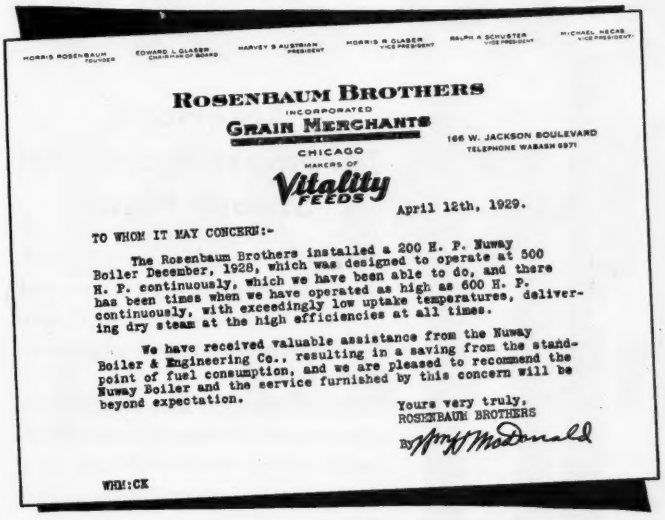
FRACTIONATING TOWERS HEAT EXCHANGERS
STEAM JET AIR PUMPS SUPERHEATERS
TUBE STILLS VACUUM PUMPS
WATER COOLED FURNACE SURFACES
BRASS AND COPPER TUBING AND PIPE



The Spirit Of The Season Prompts
Us To Express To You Our Best
Wishes For A Merry Christmas
And A Happy, Prosperous New Year

Henry Vogt Machine Co.
Louisville, Kentucky.

Ordinary NUWAY Operation!



ROSENBAUM BROTHERS
INCORPORATED
GRAIN MERCHANTS
CHICAGO
166 W. JACKSON BOULEVARD
TELEPHONE WABASH 6971
MAKERS OF
Vitality FEEDS

April 12th, 1929.

TO WHOM IT MAY CONCERN:-

The Rosenbaum Brothers installed a 200 H. P. Nuway Boiler December, 1928, which was designed to operate at 500 H. P. continuously, which we have been able to do, and there has been times when we have operated as high as 600 H. P. continuously, with exceedingly low uptake temperatures, delivering dry steam at the high efficiencies at all times.

We have received valuable assistance from the Nuway Boiler & Engineering Co., resulting in a saving from the standpoint of fuel consumption, and we are pleased to recommend the Nuway Boiler and the service furnished by this concern will be beyond expectation.

Yours very truly,
ROSENBAUM BROTHERS
By Wm. J. MacDonald

WHM:CK

The NUWAY performance record embodied in this letter at the left is typical. Note that it includes—

300% Continuous Rating
Dry Steam Delivered
Low Uptake Temperatures
Savings in Fuel Consumption
High Efficiencies

These advantages are available for your plant, too.

Consult NUWAY Before You Buy or Specify

NUWAY BOILER & ENGINEERING CO.
333 No. Michigan Ave., Chicago

NUWAY BOILERS
CONTROLLED CIRCULATION

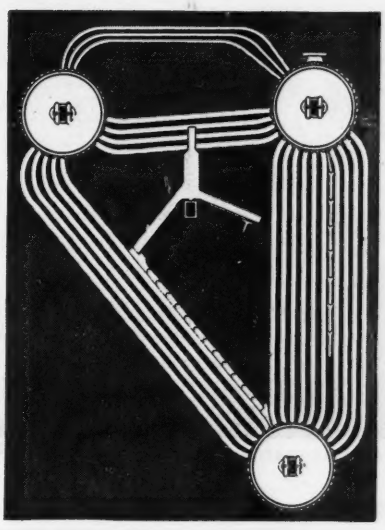
WICKES THREE DRUM BOILERS

Curved Tube Boilers are preferred by many engineers and boiler users to meet certain plant requirements.

Where water conditions make necessary the frequent cleaning of internal heating surface, accessibility by the removal of manhole covers is highly desirable.

Among curved tube boilers, the Wickes Three Drum is of outstanding design—simple and efficient. Its improved arrangement of heating surface has resulted in improved performance.

In this boiler, because of positive water circulation and equalization,



the water levels are known even at high ratings.

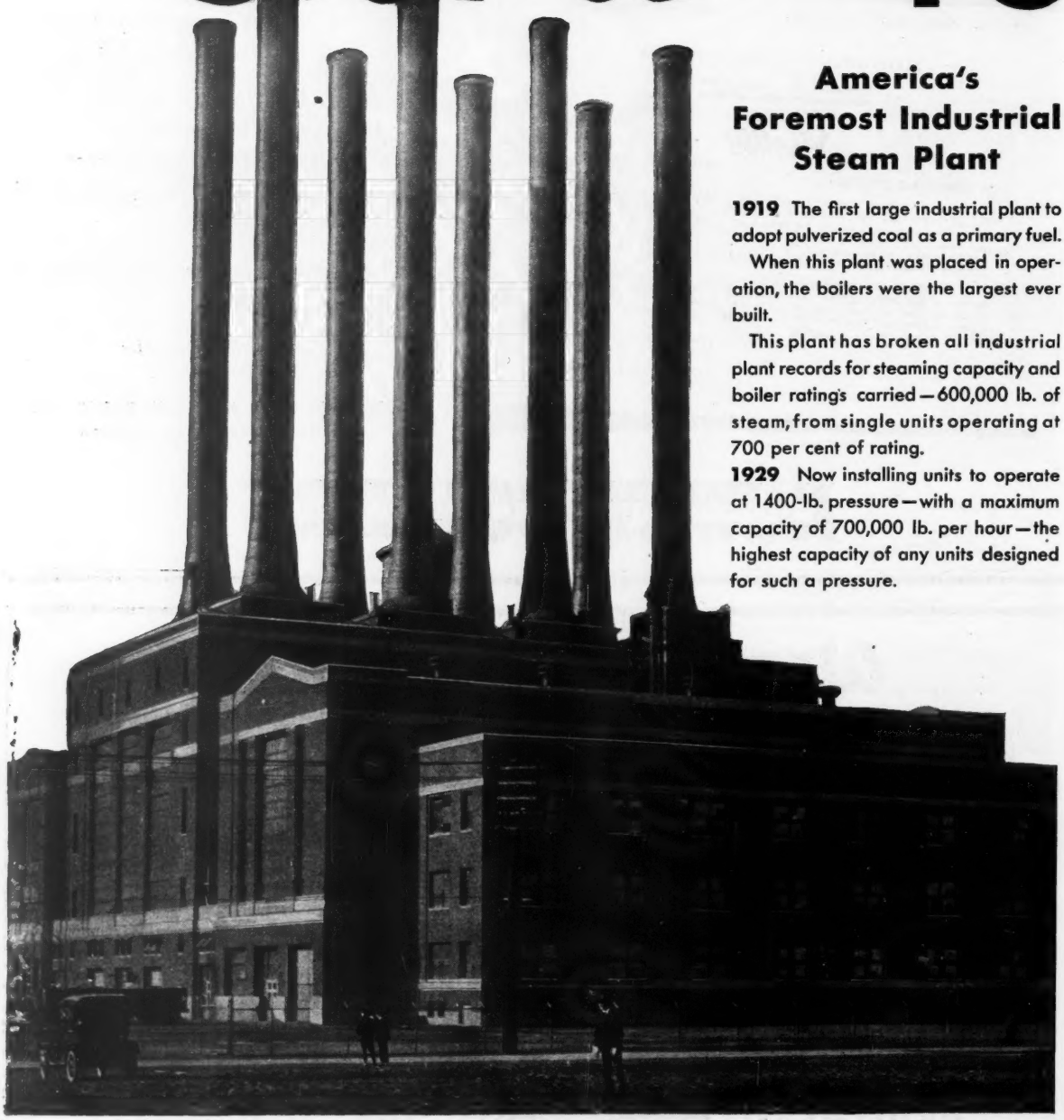
The steam generated in a Wickes Three Drum Boiler is delivered to the outlet nozzle from tubes in a high temperature gas zone. The moisture in the steam is removed and a few degrees of superheat added. This is an integral superheater.

A Curved Tube Boiler design with distinct advantages—a Wickes product—a proven unit.

The Wickes Three Drum Boiler is clearly described and illustrated in Bulletin No. 14. Write for a copy.

THE WICKES BOILER CO.
Established in 1856
SAGINAW, MICHIGAN
SALES OFFICES:
New York, 501 Fifth Ave. Chicago, 33 S. Clark St.
Pittsburgh, 1218 Empire Bldg. Seattle, 736 Henry Bldg.
Detroit, General Motors Bldg.

Ford —TO



America's Foremost Industrial Steam Plant

1919 The first large industrial plant to adopt pulverized coal as a primary fuel.

When this plant was placed in operation, the boilers were the largest ever built.

This plant has broken all industrial plant records for steaming capacity and boiler ratings carried—600,000 lb. of steam, from single units operating at 700 per cent of rating.

1929 Now installing units to operate at 1400-lb. pressure—with a maximum capacity of 700,000 lb. per hour—the highest capacity of any units designed for such a pressure.

COMBUSTION

INSTALL 1400-lb pressure

The two Combustion Steam Generating units to be installed at the Fordson Plant of the Ford Motor Company, represent the latest practice in steam generation.

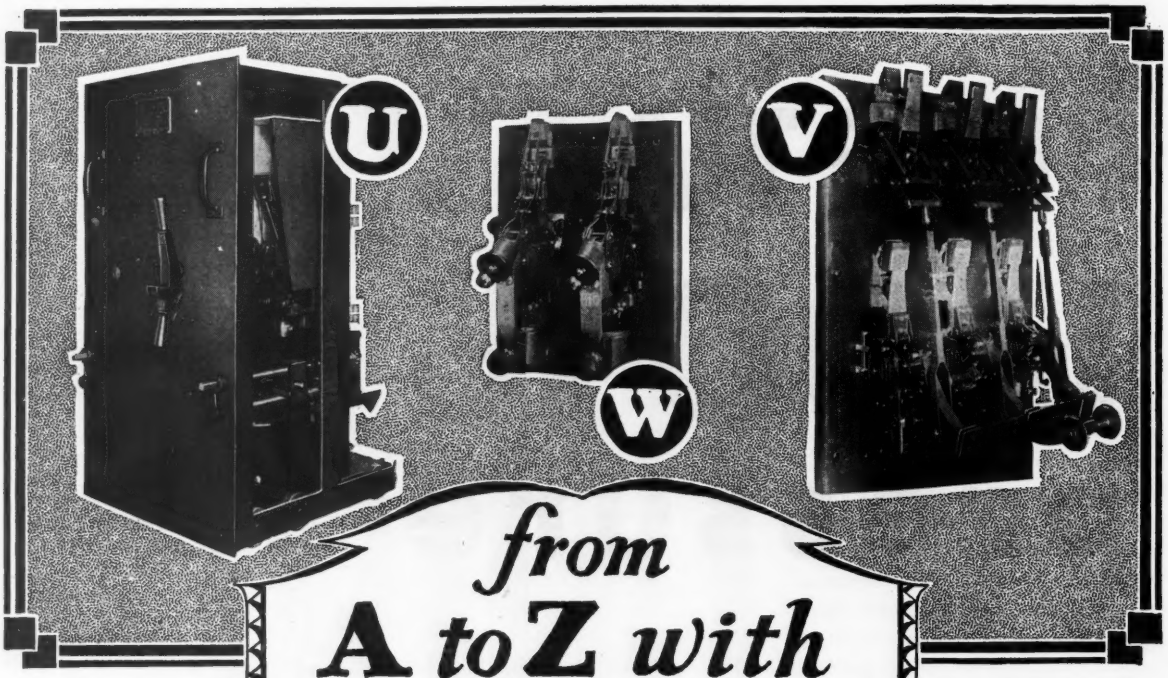
These units designed to operate at 1400-lb. pressure will each have a maximum capacity of 700,000 lb. of steam per hour—the highest steaming capacity of any units to operate at this pressure—and the steam will be superheated to a temperature of 750 degrees fahrenheit.

Lopulco Pulverized Fuel Systems (Storage type) provide the firing method. The furnaces will be of the C-E Fin tube type (water-cooled) and C-E plate type Air Preheaters will be installed to use the heat of the exit gases for preheating the combustion air.

Approximately a half million square feet of boiler heating surface is now fired by Lopulco Pulverized Fuel Systems at the various Ford Plants.

COMBUSTION ENGINEERING CORPORATION
International Combustion Building · 200 Madison Ave., New York
A SUBSIDIARY OF INTERNATIONAL COMBUSTION ENGINEERING CORPORATION

ENGINEERING



from A *to* Z *with* I·T·E

Coming Attractions

X *Type LG circuit breaker*—2000 amperes at 220 volts A. C. 2 phase 4 wire — 4 poles—4 direct-acting overload coils with 4 direct-acting time limits (Dalites) — non-closable on overload or short circuit (Autoite).

Y *Type S circuit breaker*—150 amperes at 250 volts D. C.—2 direct-acting overload coils with 2 direct-acting time limits (Dalites)—poles close independently, but trip together.

Z *Padlocked U-Re-Lite*—to prevent unauthorized changes of overload setting and also to protect men working on the line.

For complete information on dependable protection for any circuit up to 750 volts D. C. or 550 volts A. C. write or call our nearest office.

"Almost to the end of my little show, only three more to go—but remember the new I-T-E catalog contains 66 pages of descriptions, dimension drawings, photographs and prices of I-T-E equipment. Great help to you in your daily work, Brother—better write my company for your copy."

U Type LL air circuit breaker truck—1600 amperes at 550 volts A.C.—fitted with wheels, racking in gear and separable contacts for easy removal from switchboard—mechanically interlocked so truck cannot be removed while breaker is closed. Truck can be racked out to 6" inspection position without breaking auxiliary control circuits.

V I-T-E semi-automatic transfer switch—400 amperes at 480 volts A. C.—automatically connects load to emergency source when normal fails—reconnected to normal source by operator. Also made in full automatic form where switch returns instantly and automatically to normal source when normal is restored.

W Type J circuit breaker—40 amperes at 250 volts D.C.—2 poles—2 direct-acting overload coils with 2 direct-acting time limits (Dalites)—poles are closed and tripped independently.

I-T-E CIRCUIT BREAKER COMPANY
19th and HAMILTON STS., PHILADELPHIA

Birmingham, American-Traders Bank Building; **Boston**, 201 Devonshire; **Buffalo**, Ellicott Sq. Bldg.; **Chicago**, 333 N. Michigan Ave.; **Cincinnati**, Union Trust Bldg.; **Cleveland**, 439 Terminal Tower Bldg.; **Dallas**, 1810 Allen Bldg.; **Denver**, Tramway Bldg.; **Detroit**, Penobscot Bldg.; **Duluth**, 611 Providence Bldg.; **Kansas City**, Midland Bldg.; **Los Angeles**, 106 W. 3rd; **Minneapolis**, Plymouth Bldg.; **Montreal**, 151 Lagauchetiere St. West; **New Orleans**, Hibernia Bank Bldg.; **New York**, 12 E. 41st St.; **Omaha**, Electric Bldg.; **Philadelphia**, 1505 Race St.; **Pittsburgh**, Park Bldg.; **St. Louis**, Bank of Commerce Bldg.; **San Francisco**, Russ Bldg.; **Seattle**, 802 33rd Ave.; **Toronto**, 149 Adelaide Street East; **Vancouver**, 500 Beatty Street.

I-T-E PROTECTION

URELITES ~ I-T-E CIRCUIT BREAKERS

Why a Sterling?

High Duty Internal Combustion Engine

Because it is the only high duty internal combustion engine possessing important characteristics as a result of 600 actual installations. Bearings carry only 20% of the loads of ordinary engines; oil coolers and filters, water cooled exhaust manifold, complete testing, are all essential. Pay the slight difference for them and start your emergency unit within a few seconds. Pump water constantly 24 hour service whenever occasion requires.

Unique application, 1 high head and 2 low head Cameron pumps in series driven by a 6 cylinder, 180-225 HP. Sterling engine turning 1400 r.p.m. at the Brown Co. plantation, West Palm Beach, Fla., for standby spraying system.

STERLING ENGINE COMPANY, Dept. C-10, Buffalo, N. Y., U. S. A.

Thirty-seven years' experience

Install a Troy Engine that is built by experts and forestall trouble, repairs and failures. Our years of experience in building steam engines only allows us to sell a high quality machine at a remarkably low cost.

Troy Engine & Machine Co.
Troy, Pennsylvania

TRADE MARK REGISTERED TROY U.S. PATENT OFFICE

Chicago Office
118 W. Ohio St.
Riley Engineering & Supply Co., Ltd., Miranda and Schell Avenues, Toronto 10, Ontario, Canada

STEAM ECONOMY

WE BUILD boilers of all types—water-tube, tubular and self-contained; also steam engines and steam turbines, and are prepared to give you the benefit of our long experience in designing, or remodeling your power plant to save fuel and use your steam twice; for power and in your processes. Our machinery is of the highest class and we have been in the engineering trade for sixty years. Do not hesitate to write us if you want only a boiler, engine or turbine at this time. We build almost all sizes.

MURRAY IRON WORKS CO.
Burlington, Iowa

Water Tube Boilers for Every Service

BOILERS of high quality for central stations and industrial plants of all sizes, and for utilization of waste heat from kilns and furnaces. Steel construction only. Straight tube and bent tube types. Noted for long life and economy of operation.

Engineering service available—wire or write.

EDGE MOOR IRON COMPANY Edge Moor, Delaware

EDGE MOOR Water Tube BOILERS

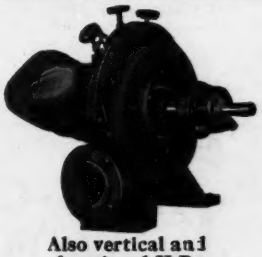
STRAIGHT AND BENT TUBE TYPES—WATER WALLS—AIR PREHEATERS

Steam Turbines

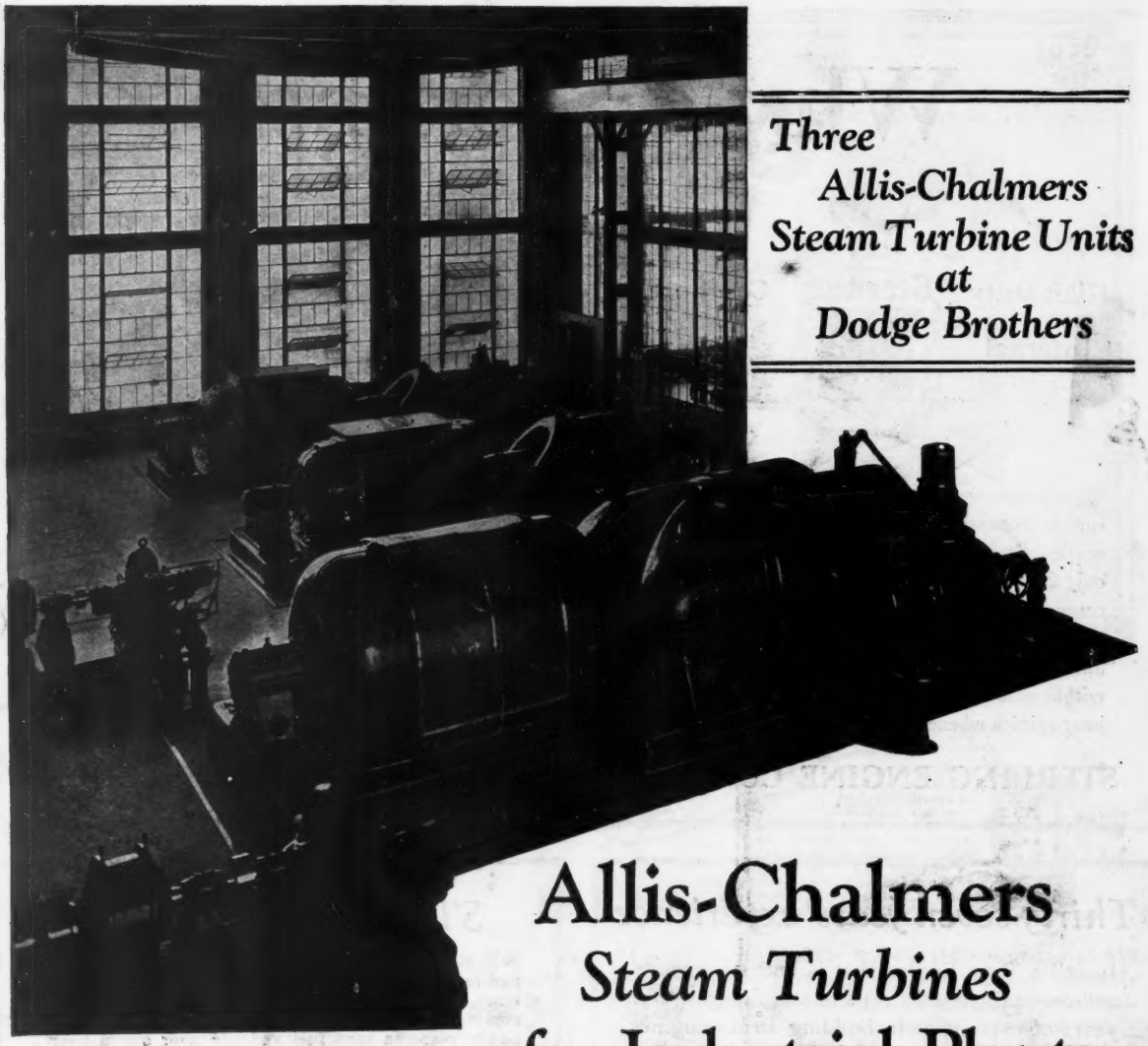
1 to 60 H.P.

Coppus Engineering Corporation

340 Park Ave.
Worcester, Mass.



Also vertical and fractional H.P.



Three Allis-Chalmers Steam Turbine Units at Dodge Brothers

Allis-Chalmers *Steam Turbines* —for Industrial Plants

Reliability is the primary requisite in power generating equipment in industry.

Allis-Chalmers Steam Turbine Units are KNOWN for reliability and efficiency.

The 10,000 K. W. Steam Turbine generator in the foreground is the fourth Allis-Chalmers unit installed in the Dodge Brothers power plant at Detroit.

A 750 K. W. unit (not shown) was installed in 1913—the two 4000 K. W. units in 1921 and the 10,000 K. W. in 1924. These repeat orders attest the satisfactory performance of A. C. Steam Turbines in actual operation.

ALLIS-CHALMERS MANUFACTURING CO.
MILWAUKEE, WIS. U.S.A.